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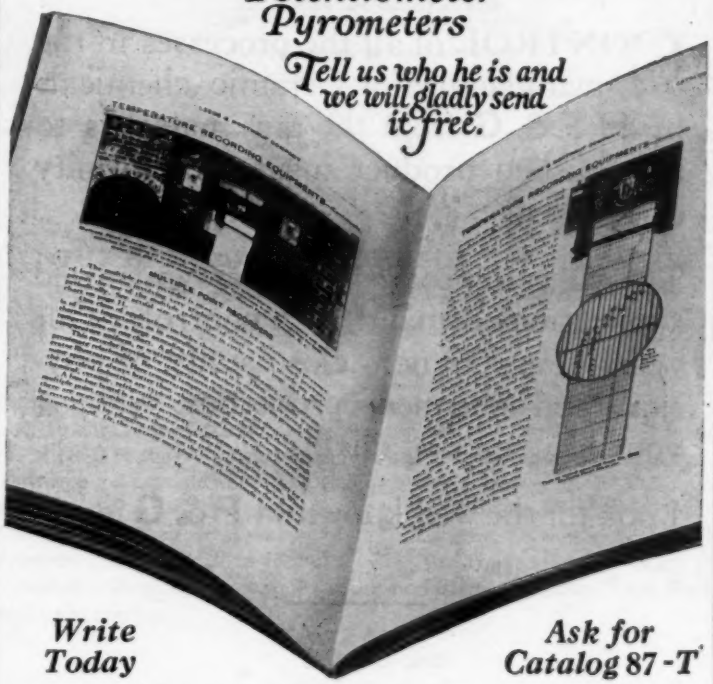

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ORIGINAL PAPERS

THE EFFECT OF VARIOUS SODIUM SILICATES AND OTHER ELECTROLYTES ON CLAY SLIPS[1]

BY SAMUEL J. MCDOWELL[2]

ABSTRACT

Attention is drawn to the fact that different brands of sodium silicate vary 250% in their soda to silica ratio. Four silicates with ratios from 1:1.8 to 1:4 were added on a basis of per cent Na_2O to slips of six clays commonly used in the whiteware industry. Rate of flow, hydrogen-ion concentration, and settling behavior were studied. Maximum rate of flow was produced in each case while the slip was acid. Those silicates high in silica were the most potent in their effect on rate of flow for a given amount of Na_2O. The effect was also more pronounced than that of NaOH, Na_2CO_3, or silica sol which were used as comparisons. Possible explanations of the mechanism of deflocculation are discussed to explain the results.

Introduction

Sodium silicate as it is used in the ceramic industry is a more or less thick syrupy liquid. It is made by fusing proper proportions of soda ash (Na_2CO_3) and sand (SiO_2) and dissolving the resulting glass in water. Soda ash and silica in all proportions where silica is present in greater amounts than the 1 : 1 molecular ratio will form glasses. Figure 1 shows the melting point diagram of this part of the

[1] Published by permission of the Director, Bureau of Standards. Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Detroit, Mich., February, 1927. (White Wares Division.) Received November 15, 1926.

[2] Superintendent, Columbus Branch, Bureau of Standards.

system Na_2O–SiO_2.[1] The approximate composition range for commercial sodium silicate glasses is also shown. Melting may start at as low as 790°C and, in a majority of cases, will be complete under 1000°C. As the silica content is raised above 77% by weight, (Fig. 1),[2] the temperature required to melt the glass goes up rapidly, and the solubility of the resulting glass in water is decreased. This fact places the high silica ratio at about 1 Na_2O : 4 SiO_2 for the commercial solutions, while the lower limit is determined at about 1 Na_2O : 1.5 SiO_2 by the tendency for sodium metasilicate ($Na_2O \cdot SiO_2 \cdot NH_2O$) to crystallize.

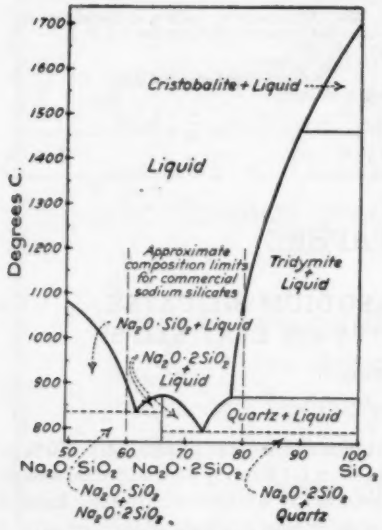

FIG. 1.—Melting point diagram of the system $Na_2O \cdot SiO_2$–SiO_2. Composition is expressed as weight per cent SiO_2.

The term sodium silicate then does not mean one definite chemical compound. It rather applies to a series of solutions one of which may have two and one-half times as much silica as another for a given soda content. The water contents of these solutions are also variable depending on the solubility of the glass; each ratio of soda to silica in the glass produces a silicate solution which has its own peculiar physical properties and resulting uses which vary considerably. A solution high in silica loses its water with comparative ease but can only be concentrated to a point where it contains about 30% solids without gelling.[3] The gelled mass has a conchoidal fracture and bounces like rubber. It flows under moderate pressure, however, and the flow-pressure curve passes through the origin. A solution high in soda loses its water slowly, but may be concentrated to a point where over 60% solids are present and still be handled and pulled into long threads. Upon further concentration the stiffness increases until the material is practically a solid but it will again become somewhat pliable under pressure.[4]

[1] G. W. Morey and N. L. Bowen, "Binary System $Na_2O \cdot SiO_2$–SiO_2", *Jour. Phys. Chem.*, **28**, 1167 (1924).

[2] Since the molecular weights of Na_2O and SiO_2 are nearly the same (approximately 62 and 60, respectively) the ratios "by weight" and "molecularly" can be used interchangeably for practical purposes.

[3] W. D. Bancroft, Applied Colloid Chemistry, McGraw-Hill Book Co.

[4] J. G. Vail, "Silicate Solutions and Some Siliceous Gels," *Soc. Chem. Ind.*, **44**, 214 (1925).

There is some question regarding the chemistry of these solutions but it is generally agreed that the metasilicate is present. One theory holds that those solutions richer in silica than the 1 to 1 ratio are mixtures of the metasilicate, more or less dissociated, and colloidal silica. The colloidal silica particles tend to coalesce or gel but the adsorption of the sodium ions on their surface reduces this tendency.[1] Another theory is that both the salts of $Na_2O \cdot SiO_2$ and $Na_2O \cdot 2SiO_2$ exist in solution and that products with other ratios are mixtures of these two salts and either "hydrated silica" or sodium hydroxide.[2]

Object of the Investigation

There has been much confusion in ceramic literature in the use of the term "sodium silicate." Some writers have specified the specific gravity used, others have spoken of concentrated solutions; both of these descriptions mean nothing definite. Only a few have mentioned the ratio of soda to silica.

Although sodium silicate is not usually used alone to deflocculate clays it is, according to Bleininger[3] and Schurecht,[4] a potent material for this purpose. The silicate which Bleininger used had a soda to silica ratio of 1:2.44. That used by Schurecht was 1:3.1. No mention is made of the effect of additions of other ratios.

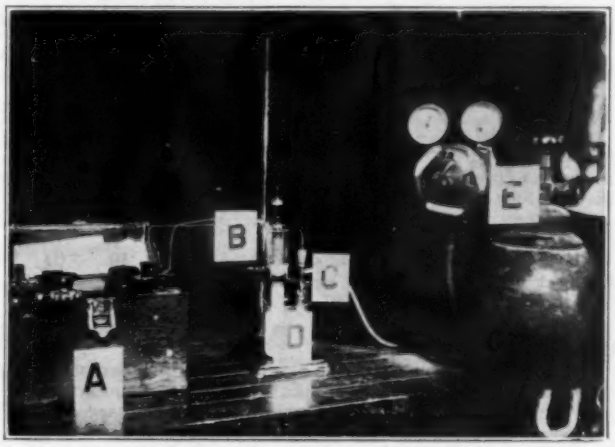

FIG. 2.—Equipment used in determining the p_H value of clay slip: A, potentiometer; B, calomel electrode with porous cup extending into the slip; C, hydrogen electrode extending into the slip and connected to the hydrogen tank by a rubber hose; D, the beaker of slip being tested; and E, the hydrogen tank.

[1] W. Stericker, "Relations of Structure to Free Alkali in Sodium Silicate Solutions", *Chem. & Met. Eng.*, **25**, 61 (1921).

[2] R. W. Harman, "Aqueous Solutions of Sodium Silicate", I & II, *Jour. Phys. Chem.*, **29**, 1155 (1925); *Jour. Phys. Chem.*, **30**, 359 (1926).

[3] A. V. Bleininger, "Use of Sodium Salts in the Purification of Clays and in the Casting Process," Bur. Stand., *Tech. Paper*, No. 51.

[4] H. G. Schurecht, "The Relations of Salt to Clay in the Purification of Clays", *Trans. Amer. Ceram. Soc.*, **19**, 460 (1917).

The present investigation was undertaken to ascertain the deflocculating effect of sodium silicates of various ratios and the four whose compositions are given in Table II are probably representative of those used in the industry. It was also later found desirable to include the effect of other electrolytes for comparison.

Procedure

Preparation of Clay Slips Each clay (Table I) was crushed through an 8-mesh screen and approximately four pounds were dried for 24 hours at 70°C. The temperature was not carried to 110°C as it was feared that this might injure the plasticity to be obtained when the clay was mixed with water. Fourteen hundred grams were weighed up with 2800 grams of distilled water. This water was not absolutely constant in its hydrogen-ion concentration, the p_H value varying from 6.0 to 6.5. The batch was mixed in a ball mill for one hour to bring the clay into suspension with a minimum of grinding. The slip was screened through a 65-mesh screen and placed in sealed jars; no water was added and none allowed to evaporate so that the ratio of water to clay (by weight) was as 2 : 1. The specific gravity of the slip was $1.25 \pm .01$.

TABLE I

CHEMICAL COMPOSITIONS OF CLAYS USED

	Loss on ignition	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2
M. W. M. Eng. china clay	13.14	45.75	38.96	.61			1.18	.29	.04
Tenn. ball clay No. 7	12.81	45.60	38.70	1.00	.12	.20	.25	.42	1.04
Georgia (Albion) china clay	13.10	45.25	38.7	.58	.21	.09	.51	.49	1.17
Florida plastic kaolin	13.46	48.82	36.78	.80	.40		.41	.14	
N. Carolina kaolin	13.42	44.72	39.66	.50	.07	.01	.94	.17	
Kentucky ball clay No. 4	12.40	49.32	32.64	1.44	.34		1.03	.29	1.00

M. W. M. English china clay is a washed secondary clay and is about average for this type.
Tennessee ball clay No. 7 is a light colored, rather plastic ball clay.
Albion (Georgia) china clay is an unwashed secondary china clay of the soft variety.
Florida plastic kaolin is a washed clay of secondary origin. It is quite plastic.
North Carolina kaolin is a washed primary kaolin and is low in plasticity.
Kentucky ball clay No. 4 is a medium dark, rather plastic ball clay.

TABLE II

CHEMICAL COMPOSITION OF THE SODIUM SILICATES USED[1]

Silicate	No. 1 %	No. 2 %	No. 3 %	No. 4 %
Na_2O	6.34	9.12	13.63	19.32
SiO_2	24.47	29.37	33.17	33.87
H_2O by difference	69.19	61.51	53.20	46.81
Molecular ratio Na_2O to SiO_2	1:4	1:3.33	1:2.52	1:1.81

[1]Analyses obtained through the courtesy of the Philadelphia Quartz Company.

Preparation of Electrolyte Solutions Three hundred and sixty grams of slip (containing 120 grams of dry clay) were taken for each determination and sodium silicate was added in increments of .005% Na_2O (per cent based on weight of clay in the slip). This is comparable to additions of approximately 0.1 of 1% of No. 1 silicate. However, since the other silicates (Table II) contained a greater percentage of Na_2O than did No. 1, less than 0.1% of silicate was added in their cases for each increment. This method of addition was thought to be the most logical since the presence of the sodium ions, with the consequent presence of hydroxyl ions, is thought to be the activating agent in deflocculation phenomena when sodium salts are used. The addition of electrolyte to the slip was based on the dry clay content rather than the water content because Schurecht[1] has shown the clay phase to be the more important. The p_H values of the silicate solutions used were as follows:

1 = 10.25
2 = 10.50
3 = 10.75
4 = 11.55

Determination of Rate of Flow One or more increments of sodium silicate solution were added to 360 grams of each slip, together with sufficient distilled water to total 400 grams. The treated slip was thoroughly shaken in a graduated cylinder and allowed to flow through an "efflux viscosimeter" of the Mariott tube type (similar to that described by Bleininger)[2] with an opening of $\frac{3}{32}$ inch. The time required for 200 cc to flow was measured with a stop-watch and checked until two readings were

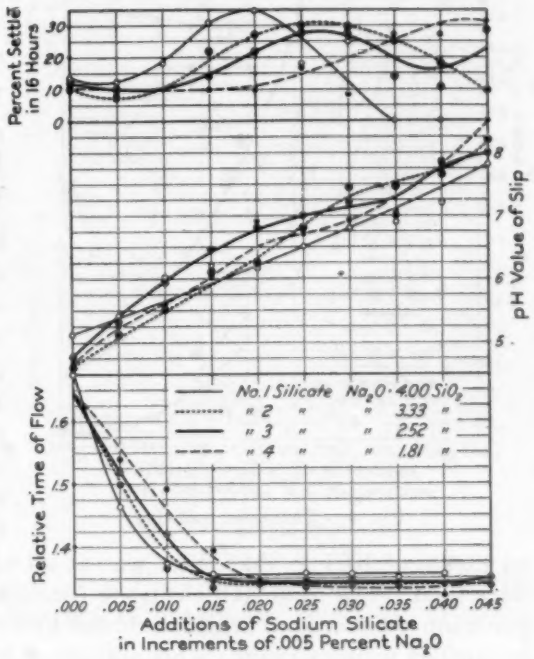

FIG. 3.—English china clay.

[1] H. G. Schurecht, *loc. cit.*

[2] A. V. Bleininger, "Use of Sodium Salts in the Purification of Clays and in the Casting Process," Bur. Stand., *Tech. Paper*, No. 51. Also, by T. G. McDougal, Bur. Mines, *Tech. Paper*, No. 126.

obtained to within $\frac{2}{5}$ of a second. The average of these two was taken as the time required, and was compared with the time required for the flow of 200 cc of water at the same temperature. (The temperature varied only $\pm 3°C$ and no correction was made for it.) The density of the water and slip being known, the quantity used as ordinates for Figs. 3 to 14 was calculated from the following formula which is the one used with the Oswald viscosimeter:

Relative time of flow (corrected for difference in density) $= ax/wt$
where a = density of liquid
w = density of water
x = time of discharge of liquid
t = time of discharge of same amount of water

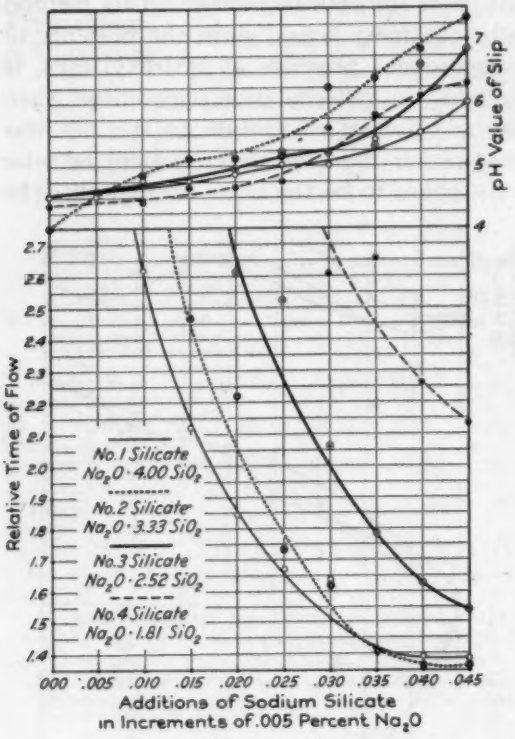
Relative Time of Flow
pH Value of Slip
No.1 Silicate Na2O·4.00 SiO2
No.2 Silicate Na2O·3.33 SiO2
No.3 Silicate Na2O·2.52 SiO2
No.4 Silicate Na2O·1.81 SiO2
Additions of Sodium Silicate in Increments of .005 Percent Na2O

FIG. 4.—Tennessee ball clay.

Hydrogen-Ion Determination The potentiometer method was used to determine the p_H value as it could be done directly on the slip itself, thus making it unnecessary to filter the material and test the filtrate as must be done in the colorimetric method. A Leeds and Northrup potentiometer, and a calomel electrode with a porous cup in which was placed an excess of KCl so that there was at all times a saturated solution, were used. The hydrogen electrode consisted of a piece of platinized platinum wire around which bubbled hydrogen which was procured in purified form in tanks. This apparatus is similar to that described by Randolph and Donnenwirth.[1] The equipment used is shown in Fig. 2.

Settling Behavior After the determination of relative time of flow and hydrogen-ion concentration, 200 cc of the

[1] D. W. Randolph and A. L. Donnenwirth, "Hydrogen-Ion Measurements on Clay Slips", *Jour. Amer. Ceram. Soc.*, 9, 541–47 (1926).

slip were placed in graduated stoppered bottles and the per cent of settling for a period of sixteen hours determined. The tests on the ball clay and plastic kaolin were unsatisfactory due to the thickness of the slip and the inability to measure accurately the small per cent of settling.

Results

Figures 3, 4, 5, 6, 7, and 8 show graphically the effect of the various sodium silicates on the rate of flow of the different slips. The corresponding p_H values and the settling behavior, when it could be ascertained, are also shown.

The rate of flow, p_H value, and settling behavior for each batch of untreated slip varied slightly; for this reason a comparison of values resulting from additions of each increment of electrolyte is difficult. However, the addition which causes the curve to flatten out, that is, attain minimum time of flow—can be determined rather closely in each case. It will be noted that this condition is produced by a smaller percentage of Na_2O when No. 1 silicate is used than is the case with any of the others, although the effects of No. 2 are similar and, in some cases, equal. The case of English china clay is typical, for which the following percentages of Na_2O are necessary to attain minimum time of flow:

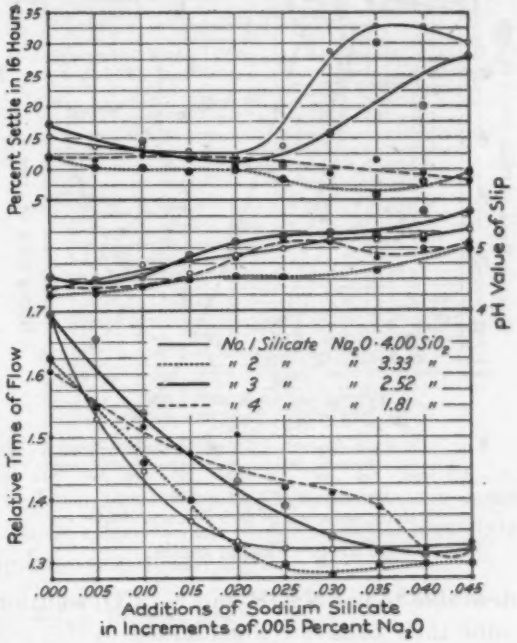

FIG. 5.—Georgia china clay.

	Per cent
For No. 1 silicate	.015
" No. 2 "	.015
" No. 3 "	.025
" No. 4 "	.030

With some clays the difference is more marked than with others, but the order of effect is the same in each case.

One thing which was unexpected was the p_H values which corresponded to the minimum time of flow figures. There was no one value where minimum time of flow occurred nor was there a break in the curve of p_H values at that point. The value varied with each clay and each silicate and ranged from 4.3 to 6.9 *occurring in each case while the slip was acid.*

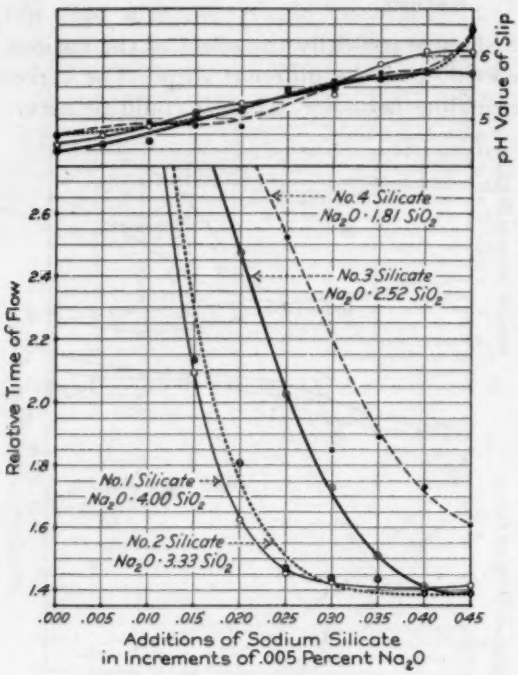

FIG. 6.—Florida kaolin.

This is different from the conditions which are thought to prevail when a clay reaches minimum time of flow. Neither does it bear out the findings of Scripture and Schramm[1] who found that, with china clays, the p_H varied from 7 to 11.7 where a $\frac{w}{c}$ ratio of $\frac{3}{2}$ was used and NaOH used as the electrolyte. Hall also found, using a $\frac{w}{c}$ ratio of $\frac{7.9}{1}$, and testing for maximum deflocculation by the settling method, that the point of maximum deflocculation was reached at a p_H value between 10 and 12 where NaOH was used.[2]

It was therefore thought desirable to use NaOH and Na_2CO_3 solutions as electrolytes and determine their behavior when added to this group of clays. The solutions were made up as before, based on the ratio of Na_2O to dry clay, except that each increment consisted of .02% Na_2O instead of .005%. The p_H values of the solution as used were:

NaOH	13.15
Na_2CO_3	11.0

The results obtained using NaOH closely checked those of Scripture and Schramm and also those of Hall. Figures 9, 10, 11, 12, 13, and 14 show the relations between the effects of No. 1 sodium silicate, NaOH,

[1] "Deflocculation of Clay Slips and Related Properties", *Jour. Amer. Ceram. Soc.*, 9 [4], 175 (1926).

[2] F. P. Hall, "Effect of Hydrogen-Ion Concentration upon Clay Suspensions," *Jour. Amer. Ceram. Soc.*, 9, 989 (1923).

Na_2CO_3 and silica sol.[1] The latter was used in an attempt to explain why the effect of sodium silicate was so much more pronounced than that of either sodium hydroxide or sodium carbonate. Assuming that silicates contain colloidal silica, it was thought that perhaps colloidal silica alone might be a deflocculating agent. It was added to various clays and the effect on rate of flow, p_H values, and settling noted as before. Unfortunately there was sufficient solution available to test only three china clays and one ball clay. As will be noted, additions of silica sol alone had little or no effect on either rate of flow, p_H value, or settling behavior.

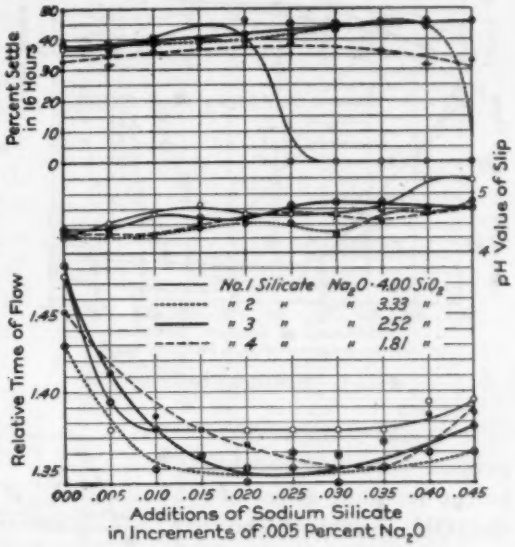

FIG. 7.—North Carolina kaolin.

An interpretation of the relation between the settling behavior and the other properties is difficult due to the somewhat erratic results obtained in some cases. There is apparently not sufficient evidence on which to base any conclusions in regard to this property. The variation in results may have been due to the absorption in some cases of some KCl solution through the porous cup of the calomel electrode and its effect on the settling behavior of the slip.

Discussion of Results

The mechanism of the dispersion of clay slips by the addition of salts is generally agreed to be connected with the presence of the hydroxyl ion. The exact rôle of this ion, however, is the subject of

[1] Through the courtesy of Richard Bradfield of the College of Agriculture, University of Missouri, a small amount of silica sol was obtained which had been prepared by him by adding dilute HCl to dilute sodium silicate and centrifuging. (Richard Bradfield, "A Centrifugal Method of Preparing Colloidal Ferric Hydroxide, Aluminum Hydroxide and Silicic Acid," *Jour. Amer. Chem. Soc.*, **44**, No. 5). It had been further purified by electro dialysis which was continued until the cathode solution no longer reacted pink to phenolphthalein. It may therefore be assumed that only SiO_2 was present. The solution as received contained 1.21 % SiO_2 and had stood three years without any apparent tendency to gel. It was made into a solution which contained the same amount of SiO_4 as the solution of No. 1 silicate used; the p_H value was 5.2.

some discussion. Bleininger[1] says that the negatively charged OH ions repel the similarly charged clay particles electrostatically. Spangenberg[2] claims that the OH ion is adsorbed by the clay particle and the so charged particles repel each other. Bole[3] suggests that the OH ion may form a hydroxyl-ion colloid absorption complex with the positively charged surface coating on the clay particle and that the then negatively charged clay particles repel each other. Mattson[4] found that the negative charge on the clay particle reached a maximum in the region of maximum deflocculation but that the actual value of this charge varied for each solution.

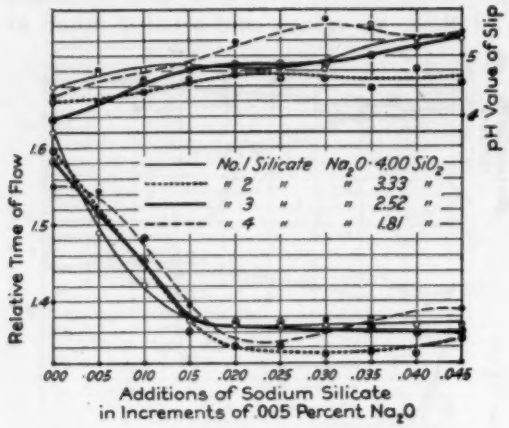
Relative Time of Flow
pH Value of Slip
No.1 Silicate Na2O·4.00 SiO2
" 2 " " 3.33 "
" 3 " " 2.52 "
" 4 " " 1.81 "
Additions of Sodium Silicate
in Increments of .005 Percent Na2O

FIG. 8.—Kentucky ball clay.

It would seem, if dispersion were due merely to the repelling effect of the OH ions and clay particles as noted by Bleininger, that a given amount of Na_2O in the form of sodium carbonate (or particularly sodium hydroxide which is highly ionized) should produce just as great or greater dispersion as does sodium silicate and at the same p_H value, but this is not the case.

If, according to Spangenberg, the OH ion is

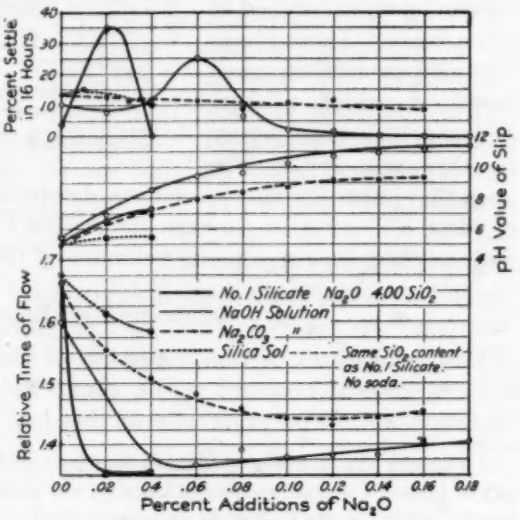
Percent Settling in 16 Hours
Relative Time of Flow
pH Value of Slip
No.1 Silicate Na2O 4.00 SiO2
NaOH Solution
Na2CO3 "
Silica Sol
Same SiO2 content as No.1 Silicate. No soda.
Percent Additions of Na2O

FIG. 9.—English china clay.

[1] Bur. Stand., *Tech. Paper*, No. 51, p. 7.

[2] A. Spangenberg, Zin Evkenntnis des Tongreszens ihren Einflusz auf die Tonverflussigung Dissertation Darmstadt 1910; J. K. Neubat, Die Tonverflussigung durch alkali.

[3] G. A. Bole, "Mechanism of Plasticity from Colloid Standpoint", *Jour. Amer. Ceram. Soc.*, **5**, 469 (1922).

[4] "Die Beziehungen zwischen Ausflockung, Adsorption und Teilchenladung mit besonderer Berücksightigung der Hydroxyleionen", *Kolloidchem. Beihefte*, **14** (9–12) 227.

adsorbed by the clay particle, which seems unlikely as both have a negative charge, NaOH again should produce dispersion just as quickly as sodium silicate and at the same p_H value.

A combination of the theories of Bole and Mattson seems to most nearly explain the results obtained in this investigation. It seems probable that hydroxyl-ion colloid absorption complexes are formed as has been suggested. When sodium hydroxide or carbonate is used, the hydroxyl ions attract the positively charged particles and ions from the surface of the clay particles until the particles of clay have developed maximum charge for that solution and we have maximum dispersion. With sodium silicates colloidal silica is present which is negatively charged. This tends to adsorb Na^+ ions and disturb the equilibrium so that the OH^- ions are more active in their formation of the hydroxyl ion absorption complexes. The clay particle therefore attains maximum charge for that solution sooner and maximum dispersion results.

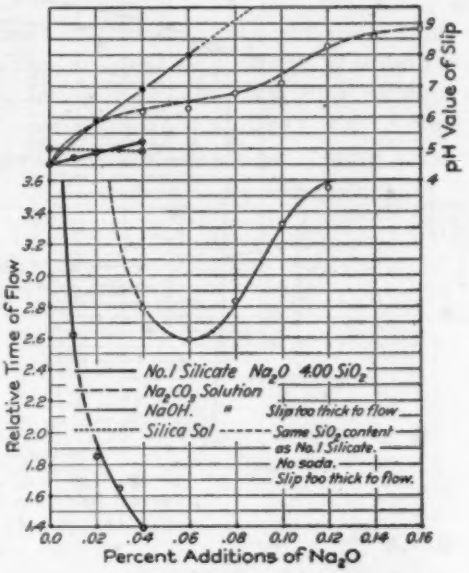
pH Value of Slip
Relative Time of Flow
No.1 Silicate Na_2O 4.00 SiO_2
Na_2CO_3 Solution
NaOH. "
Silica Sol
Slip too thick to flow
Same SiO_2 content as No.1 Silicate. No soda.
Slip too thick to flow.
Percent Additions of Na_2O

FIG. 10.—Tennessee ball clay.

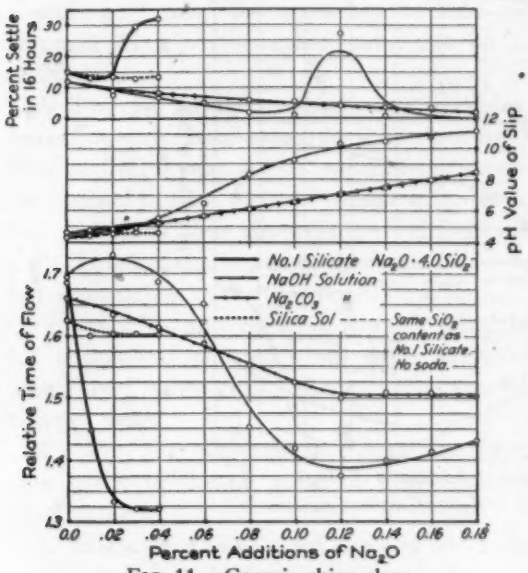
Percent Settle in 16 Hours
pH Value of Slip
Relative Time of Flow
No.1 Silicate $Na_2O \cdot 4.0 SiO_2$
NaOH Solution
Na_2CO_3 "
Silica Sol
Same SiO_2 content as No.1 Silicate. No soda.
Percent Additions of Na_2O

FIG. 11.—Georgia china clay.

For this reason there is a different p_H value for each clay and each electrolyte where maximum charge on the particles is attained and with the use of sodium silicates, particularly those high in silica, the action is more pronounced for a given

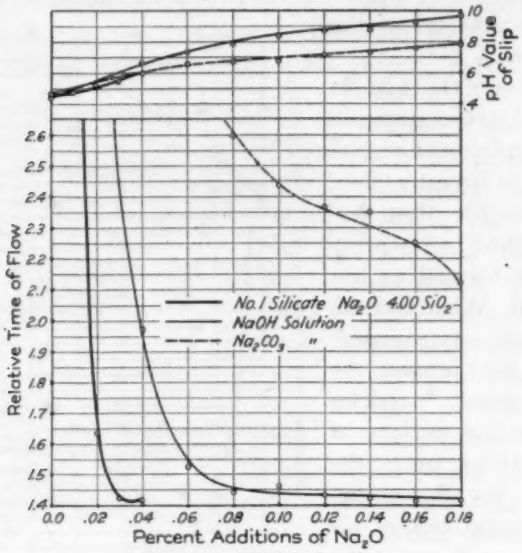

FIG. 12.—Florida kaolin.

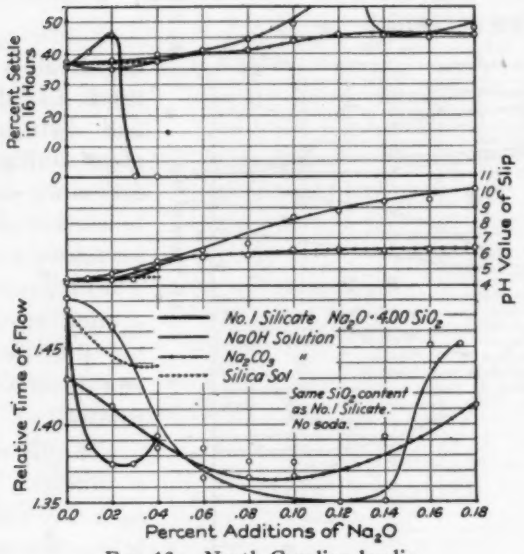
Percent Settle in 16 Hours
pH Value of Slip
Relative Time of Flow
No. 1 Silicate $Na_2O \cdot 4.00\ SiO_2$
NaOH Solution
Na_2CO_3 "
Silica Sol
Same SiO_2 content as No. 1 Silicate. No soda.
Percent Additions of Na_2O

FIG. 13.—North Carolina kaolin.

amount of Na_2O. There is not, however, a break in the p_H curve at 7 as predicted by Bole but in view of Mattson's work this does not seem probable.

It has been noted by shop men that sodium silicate used alone produces "stringy" slip while sodium carbonate produces slip with a high surface tension if both are brought to minimum time of flow. This would be expected from the curves in Figs. 9, 10, 11, 12, 13, and 14, which show that a slip treated with sodium silicate has a much lower time of flow than the same slip treated with sodium carbonate. It will be noted also that much more Na_2O is required in the case of the carbonate.

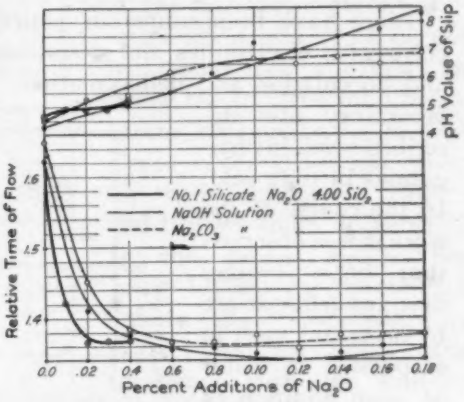

FIG. 14.—Kentucky ball clay.

Conclusions

1. Sodium silicates low in soda and high in silica between the ratios 1 : 3.33 to 1 : 4 are the most effective deflocculating agents for a given Na_2O content. It must be remembered that these silicates contain a large amount of water and therefore it may be necessary to add more of this type of silicate solution than of the other solutions to introduce the same amount of Na_2O.

2. The p_H value at which clay particles attain maximum charge is lower for sodium silicate solutions than for NaOH or Na_2CO_3 solutions. The probable reason that sodium silicate is a more potent deflocculating agent is due to the presence of colloidal silica which adsorbs the Na^+ ions thus disturbing their equilibrium with the OH^- ions and allowing the latter to become more active in forming hydroxyl-ion complexes with the positive charged particles and ions on the clay particles and allowing the clay particles to reach maximum charge for that particular solution. It is therefore necessary to specify the agent used when giving the p_H value at which a clay reaches minimum time of flow.

3. For the clays of this investigation, and when sodium silicate was used, minimum time of flow occurred while the slip was acid (p_H value < 7).

4. Silica sol (SiO_2) used alone is not a deflocculating agent.

5. The use of high silica sodium silicate rather than sodium carbonate would seem desirable especially where soda blisters are a difficulty.

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THE BEHAVIOR OF FELDSPAR AND FLINT WITH ACIDS AND BASES[1]

By E. W. Scripture, Jr.

ABSTRACT

On addition of acids and bases to fine-ground feldspar or flint, the same phenomena are observed as with clays, *i.e.*, flocculation, deflocculation, and absorption. The effects are less sharp than with clays, the zone of deflocculation covering a wider range of p_H and flocculation occurring at lower p_H (greater acidity). The sensitiveness of flint and feldspar to reagents increases with fineness of grinding.

There have been numerous papers dealing with the behavior of clays with electrolytes and describing the phenomena of absorption and flocculation and deflocculation. In an earlier paper[2] from this laboratory are described some investigations in that field. In the course of the work it was observed that finely ground flint and feldspar are by no means inert in suspension in water or upon addition of acids and alkalis, but exhibit the same phenomena as clays; we must regard absorption and flocculation as common to materials approaching colloidal dimensions rather than as special properties of clay. Particle size studies have shown that feldspar and flint as ground for potters' use contain fractions comparable with the finer portion of clay. It therefore becomes a matter of interest to inquire concerning the behavior of these materials with electrolytes used for the control of body slips.

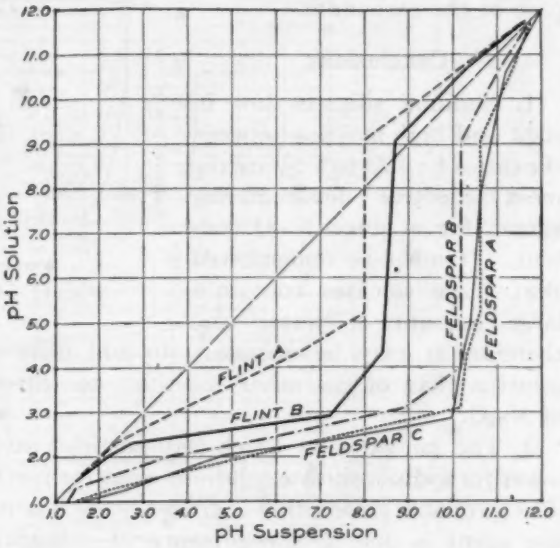

FIG. 1.

For this purpose 20% suspensions were made up in a series of tall test tubes, treated with varying quantities of NaOH or HCl, and allowed to stand for eighteen hours. The absorption of acid or alkali

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (White Wares Division). Received January 14, 1927.

[2] E. W. Scripture, Jr. and E. Schramm, *Jour. Amer. Ceram. Soc.*, 9 [4],175–84 (1926).

TABLE I

	Feldspar A					Feldspar B					Feldspar C				
p_H Solution	p_H Suspension	[H+] solution–[H+] suspension Mols per l.	Height Clear	Height Sediment	Turbidity	p_H Suspension	[H+] solution–[H+] suspension Mols per l.	Height Clear	Height Sediment	Turbidity	p_H Suspension	[H+] solution–[H+] suspension Mols per l.	Height Clear	Height Sediment	Turbidity
13.1	13.1	−0.0028	0.6	6.3	0.19	13.1	−0.0032	2.9	7.3	0.04	13.1	−0.0030	1.2	7.9	0.06
12.1	—	—	—	—	—	—	—	—	—	—	12.1	−0.00010	0.3	5.4	0.27
11.8	11.8	−0.00010	0.5	5.2	0.25	11.8	−0.00023	0.6	6.6	0.09	—	—	—	—	—
10.6	11.3	+0.00070	0.5	5.1	0.25	11.0	+0.00020	0.6	5.5	0.09	11.2	+0.00055	0.3	5.3	0.28
9.1	10.6	+0.00082	0.5	5.1	0.24	10.2	+0.00034	0.7	5.5	0.09	—	—	—	—	—
7.9	—	—	—	—	—	—	—	—	—	—	10.6	+0.00075	0.4	5.3	0.28
7.1	10.6	+0.00082	0.4	4.8	0.24	10.2	+0.00022	0.7	5.7	0.09	—	—	—	—	—
6.9	—	—	—	—	—	—	—	—	—	—	10.5	+0.00065	0.4	5.0	0.28
5.1	10.6	+0.00082	0.5	5.0	0.23	10.2	+0.00015	0.6	5.5	0.09	10.4	+0.00062	0.3	5.0	0.27
4.2	10.3	+0.00063	0.5	5.6	0.23	10.2	+0.00018	0.6	5.6	0.09	10.2	+0.00059	0.5	5.4	0.25
3.1	10.2	+0.00083	0.4	5.6	0.23	8.9	+0.00012	0.6	5.6	0.09	—	—	—	—	—
2.9	—	—	—	—	—	—	—	—	—	—	10.0	+0.0011	0.5	5.3	0.25
2.3	6.7	+0.0040	0.5	5.6	0.23	5.3	+0.0039	5.9	7.0	0.01	6.7	+0.00045	0.7	6.6	0.17
2.0	5.4	+0.0091	2.4	7.3	0.01	3.6	+0.0090	19.1	7.8	0.01	4.8	+0.0100	18.2	7.9	0.00
1.3	2.3	+0.0429	18.2	7.9	0.02	1.5	+0.0173	19.6	6.5	0.01	2.6	+0.0450	17.7	8.6	0.03
1.0	1.4	+0.0536	18.8	7.3	0.02	1.3	+0.0187	19.4	7.1	0.02	1.5	+0.0542	18.1	8.0	0.03

was determined by titration of a portion of the clear liquid or comparison with standard indicators; flocculation or deflocculation was determined by means of three observations: (*a*) the height of clear liquid, (*b*) the height of sediment, (*c*) the turbidity determined by evaporation of a 20 cc portion withdrawn from a level 16 cm below the top (the total height of the column being 26 cm). These observations are given for three feldspars in Table I and for two flints in Table II. In the tables p_H solution $=\log 1/[H^+]$ for the original liquid; p_H suspension $=\log 1/[H^+]$ for the liquid after treatment with the flint or feldspar. (See Tables I and II.)

With a large addition of alkali (high p_H) we observe flocculation on the alkaline side analogous to the so-called salting out effect with clays. In this condition the sediment is loose and the liquid clear or only slightly turbid. With smaller additions of alkali and passing over to the side of acid addition (low p_H of solution) we have a wide deflocculated zone with constant p_H of suspension, representing absorption and buffer action of the suspension; this condition is characterized by compact sediment and turbid liquid above, and represents what is obtained ordinarily with suspensions in water. With further acid ad-

TABLE II

Flint A (Sand)						Flint B (Rock)					
p_H Solution	p_H Suspension	$[H^+]$ solution–$[H^+]$ suspension Mols per l.	Height Clear	Height Sediment	Turbidity	p_H Suspension	$[H^+]$ solution–$[H^+]$ suspension Mols per l.	Height Clear	Height Sediment	Turbidity
13.1	13.1	−0.0060	19.0	7.1	0.06	13.1	−0.00420	18.5	7.9	0.07
12.1	12.1	−0.0029	0.5	6.5	0.18	12.1	−0.00289	0.6	7.8	0.15
10.7	10.2	−0.0005	0.6	6.4	0.18	10.3	−0.00034	0.6	6.6	0.14
9.1	8.0	−0.000013	0.6	6.5	0.17	8.7	−0.000006	0.6	6.6	0.14
7.1	8.0	+0.0000009	0.6	6.1	0.17	8.6	+0.000007	0.7	6.8	0.14
5.2	8.0	+0.000011	0.6	6.2	0.17	8.5	+0.000016	0.6	6.7	0.13
4.3	6.5	+0.000073	0.5	4.9	0.12	8.4	+0.000088	0.5	5.4	0.08
2.9	3.6	+0.00009	1.9	5.8	0.01	7.2	+0.0015	0.5	5.9	0.07
2.3	2.35	+0.0010	13.2	6.1	0.00	2.7	+0.0032	2.0	6.1	0.01
2.0	2.05	+0.0010	17.3	6.0	0.00	2.2	+0.0034	2.4	6.0	0.00
1.4	1.4	+0.0014	18.2	6.0	0.01	1.4	+0.0040	13.0	7.1	0.00
1.0	1.0	+0.0017	20.2	5.8	0.01	1.0	+0.0041	19.8	6.6	0.01

TABLE III

Feldspar A—2,000 Revolutions						Feldspar A—6,000 Revolutions					Feldspar A—10,000 Revolutions				
p_H Solution	p_H Suspension	$[H^+]$ solution–$[H^+]$ suspension Mols per l.	Height Clear	Height Sediment	Turbidity	p_H Suspension	$[H^+]$ solution–$[H^+]$ suspension Mols. per l.	Height Clear	Height Sediment	Turbidity	p_H Suspension	$[H^+]$ solution–$[H^+]$ suspension Mols per l.	Height Clear	Height Sediment	Turbidity
4.2	10.2	+0.00059	0.4	5.6	0.14	10.3	+0.00070	0.5	5.6	0.21	10.3	+0.00063	0.5	5.6	0.23
1.0	1.2	+0.0353	5.3	8.0	0.02	1.3	+0.0466	6.0	8.0	0.02	1.4	+0.0536	18.8	7.3	0.02

ditions we find pronounced flocculation resulting in a loose sediment and clear liquid. This corresponds to the ordinary flocculated condition of clays but occurs further on the acid side.

In Table III is shown the effect of increasing fineness of grinding on the behavior of feldspar A.

We note increased absorption with greater proportion of fines as well as flocculation at a higher p_H.

Part of the data of Tables I and II are plotted in the curves, Figs. 1 and 2. From Fig. 1 it is noted that flint and feldspar in general render the solution more alkaline, the effect being greater with the feldspar. In Fig. 3 the p_H of the solution is plotted against p_H of the suspension for a typical flint, feldspar, and china clay, the data for the latter being taken from the earlier work.[1] Within the usual range of p_H the clay causes a decrease while the flint and feldspar cause an increase of alkalinity. In combining these materials into a body mix we may therefore expect a mutual neutralization and a smaller displacement of the p_H of the water than would obtain with either material alone.

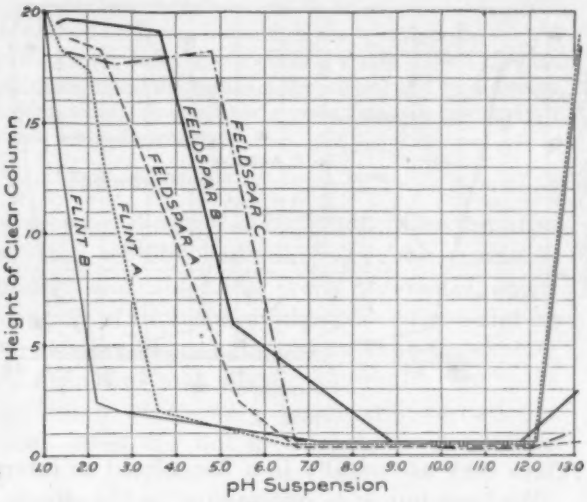

FIG. 2.

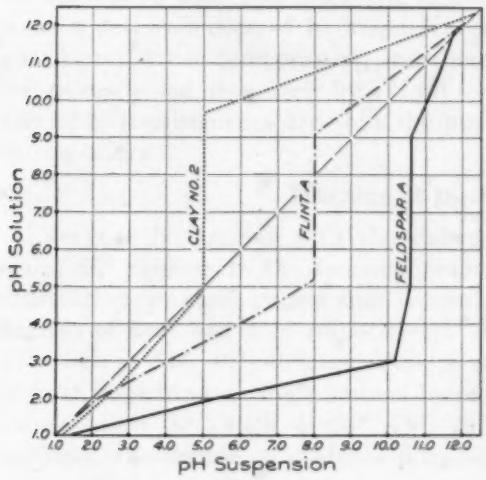

FIG. 3.

In Figs. 2 and 4 are plotted the height of clear column (as a measure of flocculation) against p_H

[1] *Loc. cit.*

of the suspension, the latter curve including earlier data on two china clays and a ball clay. On adding alkali to an acid suspension the flints deflocculate at a lower p_H than the feldspars and, correspondingly are reflocculated earlier on the alkaline side. The clays, for the most part, deflocculate at higher p_H than the feldspars or flints; while suspensions of the latter in water are always in the deflocculated range, in the case of clays they are usually in a flocculated or intermediate condition.

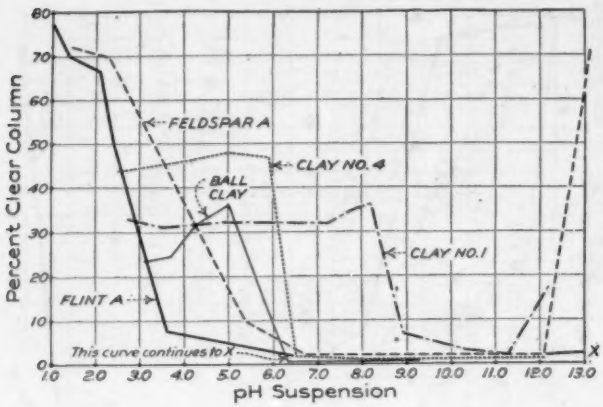

FIG. 4.

We have but little information on the effects produced upon mixing different materials of known behavior into body slips; from several experiments it appears that the result of such mixture is to promote flocculation at a higher p_H than obtains for either material alone.

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HYDROGEN-ION CONTROL IN CERAMICS[1]

By W. A. Taylor

ABSTRACT

Many technical, as well as nontechnical, men hesitate to use hydrogen-ion control because they feel that its application requires the services of a highly trained chemist. This paper shows, by a simple nontechnical discussion of the subject and by a demonstration of the method of making measurements, that a plant foreman can apply it just as easily and accurately as a trained chemist.

Introduction

In control of slips for casting, dipping or for plastic working after dewatering, it is found that acidity and alkalinity are extremely important factors. Acidity and alkalinity were previously determined and regulated by means of litmus and other test papers and by titration. Hydrogen-ion measurements have shown that these older methods often give very erroneous and misleading results, and have explained why many processes which were apparently carried out under the same conditions often did not give products of uniform quality.

Although hydrogen-ion control has proved its value and has therefore been adopted by workers in practically every line of research and industrial work, many manufacturers still hesitate to use it, since they feel that its application requires the services of a highly trained chemist. We shall show that this is not the case. In fact it is just as simple to make a determination of hydrogen-ion concentration as it is to make a measurement of temperature, and these determinations can be made just as easily and accurately by a plant foreman as by a trained chemist. The only requirements are that the operator be able to read and to match colors.

Meaning of p_H Scale

Everyone is familiar with the Fahrenheit thermometer. On this scale, 32° represents the freezing point of water. For the sake of illustration, we shall assume that values above and below 32° represent degrees of heat and cold respectively. Thus, any values higher than 32°, such as 34°, 36°, 40°, etc., denote an increase in heat, the degree of heat increasing as the numbers increase. On the other hand, any values below 32°, such as 30°, 28°, 20°, etc., denote an increase in coldness, the degree of coldness increasing as the numbers decrease.

In a similar manner the degree of acidity or alkalinity of a solution is expressed by the hydrogen-ion or p_H scale. Instead of being called degrees, as in the case of the thermometer, the units on this scale are

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (White Wares Division.) Received January 15, 1927.

called p_H values. It is apparent that it is not necessary for a person to know the derivation of the term "degree Fahrenheit" in order to determine the temperature of a solution. It is equally true that the worker need not know the meaning of the term "p_H" in order to use this method for measuring acidity and alkalinity. On the hydrogen-ion scale, a value of p_H 7.0 represents neutrality. This means that if the material being tested has a p_H of 7.0 it is neither acid nor alkaline.

Following the illustration of the thermometer given above, any values higher than p_H 7.0, such as 7.2, 7.4, 8.0, 9.0, 10.0, etc., denote alkalinity, the degree of alkalinity increasing as the numbers increase. Analogously, any value lower than p_H 7.0, such as 6.8, 6.6, 6.0, 4.0, 2.0, etc., denote acidity, the degree of acidity increasing as the numbers decrease. This will be clear from Fig. 1.

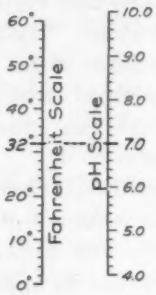

FIG. 1.

A p_H value is therefore simply a number denoting the degree of acidity or alkalinity of a solution, and an operator will learn in a few days to use this term just as intelligently as he does the term "degree Fahrenheit." To give a concrete example, let us say that a solution has a p_H value of 7.6. The solution is of course slightly alkaline. If another has a p_H of 8.2 it is more alkaline than the one of p_H 7.6. It is therefore clear that an acid or acid salt must be added to a solution of p_H 8.2 to bring it to a p_H of 7.6 and that larger quantities must be added to bring it to the neutral point of 7.0, or to an acidity of p_H 6.6, 6.0, etc. Similarly, if a solution has a p_H of 6.0 it is acid and it is necessary to add alkali to it in order to bring it to the neutral point p_H 7.0, or to an alkaline value such as p_H 8.0, etc.

Since we have explained the meaning of the p_H scale, and the way in which a solution is changed from one p_H value to another, all that is required is that the operator know what p_H value should be maintained in a given operation and how to make the measurements.

Making Determinations

Color Indicators The principle of making p_H measurements is based on the fact that various indicators change in color when they are acted upon by solutions of different acidities or alkalinities. Litmus paper is probably the simplest and most universally known example of an indicator. Its color change is from red to blue. That is, if litmus paper is dipped into an acid solution, it turns red. If it turns only slightly red, we say the solution is "slightly" acid. If it turns deep red we say the solution is "strongly" acid. Similarly if the paper turns blue, we say the solution is "slightly" or "strongly" alkaline. These are very vague and indefinite terms

and their meaning varies enormously, depending largely on the personal opinion of the worker. Thus, what is "slightly" acid to one worker might be considered as "strongly" acid by another, and vice versa.

In making p_H measurements, we simply substitute definite p_H values, such as 3.0, 6.0, 6.8, 7.4, 9.6, etc., for the indefinite terms "strongly" and "slightly" acid and alkaline. These p_H values can be recorded and can be duplicated at any time by the same or different workers.

Theoretically, litmus and other test papers can be used for determining the p_H of a solution. In practical application, however, the error is too great. One of the chief reasons for the inaccuracy of litmus is that the range is so wide (p_H 4.6 to 8.4) that the intermediate color changes are not distinct. It is practically impossible to tell the difference in the colors produced by solutions having p_H values which differ by 1.0 p_H unit. In fact, it has been shown in actual practice that solutions which specially prepared litmus indicated to be alkaline were really acid, and vice versa, when accurate p_H measurements were made on the same solutions.

Some other test papers are more sensitive than litmus but it is very doubtful whether differences of less than 0.6 p_H can be detected by their use. Even this degree of accuracy is seldom obtainable, as it is exceptional to obtain two batches of test papers which will give the same readings. Granting that a uniform paper can be obtained, we have no standards by which to judge. Thus a shade which would be considered as corresponding to a p_H value of 6.0 by one worker, might be considered as 6.6 by another. Since variations as large as 0.2 p_H may be of serious consequence, the need for an accurate method is apparent.

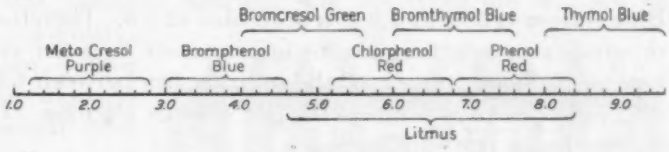

FIG. 2.

As stated above, litmus is very insensitive partly because it covers such a wide range. In order to make accurate p_H determinations it is, therefore, necessary to employ indicators with short ranges, so that the color changes are more distinct. This means that we need a number of indicators to cover the entire p_H range 1.2 to 9.6. A complete set of indicators, which were developed for just this purpose, are given, with their respective p_H ranges and color changes, in the following table. Figure 2 will make this even clearer.

The color changes of these indicators are similar to that of litmus. For example, litmus is deep red in an acid solution (p_H 4.6) and deep

blue in an alkaline solution (p_H 8.4). Similarly, Chlorphenol Red has a yellow color at p_H 5.6 and a deep red color at p_H 2.8; Bromthymol Blue is yellow at p_H 6.0 and deep blue at p_H 7.6, etc.

Name	p_H Range	Color Change
Meta Cresol Purple	1.2–2.8	red–yellow
Bromphenol Blue	3.0–4.6	yellow–blue
Bromcresol Green	4.0–5.6	yellow–blue
Chlorphenol Red	5.2–6.8	yellow–red
Bromthymol Blue	6.0–7.6	yellow–blue
Phenol Red	6.8–8.4	yellow–red
Cresol Red	7.2–8.8	yellow–red
Thymol Blue	8.0–9.6	yellow–blue

Rough Tests

If the worker has no idea of the p_H value of a given solution, it is necessary to first make a rough determination. For this work solutions of the various indicators given in the preceding table are required. To make the test, fill a graduated test tube to the mark (10 cc) with the solution to be tested, and add 0.5 cc of Bromthymol Blue indicator solution. This indicator is tried first since it has a p_H range of 6.0–7.6 and, therefore, covers the neutral point p_H 7.0. Hence it is possible by means of this one indicator to determine whether the solution being tested is neutral, acid, or alkaline. The color change of Bromthymol Blue is from yellow at 6.0 to a deep blue at 7.6. Therefore, if on adding this indicator solution, a color intermediate between yellow and deep blue is obtained, the p_H of the solution lies between 6.0 and 7.6, and it is either neutral or very slightly acid or alkaline. In this case no further rough tests are necessary.

If, however, a yellow color is obtained on adding the Bromthymol Blue indicator solution, the p_H of the solution is at least 6.0 and possibly lower. This is due to the fact that p_H 6.0 is the acid end of the range of this indicator. Even if the solution had a p_H of 5.0 or 4.0, it would still give a yellow color with Bromthymol Blue. If then a yellow color is obtained, 0.5 cc of the Bromcresol Green indicator solution, which, it will be seen by reference to the table, covers a more acid part of the range (p_H 4.0–5.6), should be added to a second test tube containing the solution of unknown p_H. The color change for this indicator is from yellow at p_H 4.0 to a deep blue at p_H 5.6. If, therefore, a color intermediate between yellow and deep blue is obtained in this test, the p_H of the solution lies between 4.0 and 5.6.

These two indicators do not cover quite all the values between 4.0 and 7.6. Thus, if Bromcresol Green (p_H 4.0–5.6) gives a deep blue color and Bromthymol Blue (p_H 6.0–7.6) a yellow color, it is apparent that the p_H of the solution lies around p_H 5.6–6.0, that is, within the range of Chlorphenol Red (p_H 5.2–6.8). This can be checked by adding 0.5 cc of Chlorphenol Red to a third sample. When this is done a color intermediate between yellow and deep red will be obtained.

Of course only one indicator should be added to each tube. That is, if Bromthymol Blue gives a yellow color, the Bromcresol Green must always be added to a fresh tube, etc. If a yellow color is obtained with Bromcresol Green, the test should be repeated using Bromphenol Blue, which covers a still more acid part of the range, p_H 3.0–4.6, etc.

If, on the other hand, on adding Bromthymol Blue indicator solution in the first test, a deep blue color was obtained, the solution is alkaline and has a p_H value of at least 7.6 and possibly higher. The test should then be repeated using Thymol Blue, which covers a more alkaline part of the range, p_H 8.0–9.6.

This procedure must of course be followed in determining the range required for any specific work, that is, a rough test must be made on solutions from all steps of the process. In this way the necessary indicators can be selected. Experience has shown that for general clay work a p_H range of 3.0 to 9.6 is required. This is covered by the six indicators, Bromphenol Blue, Bromcresol Green, Chlorphenol Red, Bromthymol Blue, Phenol Red, and Thymol Blue.

Accurate Measurements

Let us assume that in the first rough test, that is, the one in which Bromthymol Blue indicator solution was added to the solution in the test tube, a color intermediate between yellow and deep blue was obtained. This would show that the p_H of the solution lies between 6.0 and 7.6. It is now a question of determining the exact p_H value. For this purpose a set of Bromthymol Blue color standards and some form of comparator are required. A set of Bromthymol Blue color standards consists of nine standard tubes and one tube of distilled water, as shown in Fig. 3.

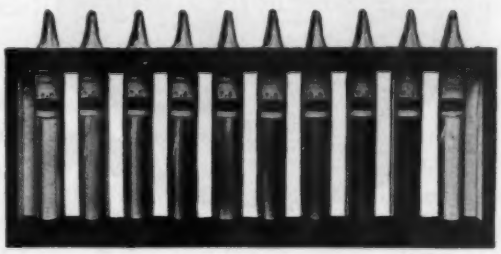

FIG. 3.—LaMotte Color Standards.

The color standards for Bromthymol Blue are simply 9 tubes, containing 10 cc of solutions of definite p_H value, that is, 6.0, 6.2, 6.4, 6.6, 6.8, 7.0, 7.2, 7.4, and 7.6, to each of which 0.5 cc of Bromthymol Blue indicator solution has been added. It is seen that these standards are made up in exactly the same manner in which the test was made, except that solutions of definite p_H values were used. These color standards can be purchased and it is, therefore, not necessary or advisable for the worker to make them up for himself.

The nine tubes are labeled with the p_H values of the various solutions which they contain. The tube marked p_H 6.0 will have a yellow color and that marked p_H 7.6 a deep blue color. The intermediate tubes, which are marked 6.2, 6.4, 6.6, etc., will have colors ranging from yellow to blue.

All that is now necessary is to match the test sample with the standards. When a match is obtained, the p_H value of the solution is read off directly from the standard with which it matches.

If the rough test had shown the p_H of the solution to lie between 5.2 and 6.8, a tube of the unknown, to which Chlorphenol Red indicator solution has been added, must of course be compared with a set of Chlorphenol Red color standards. These are similar to the Bromthymol Blue standards. Thus the tube marked p_H 5.2 has a yellow color and that marked p_H 6.8 has a deep red color. The intermediate tubes have colors ranging from yellow to red. Analogously, if the p_H of the solution were found to be between 4.0 and 5.6, the tube to which the Bromcresol Green indicator solution was added must be compared with the Bromcresol Green color standards, etc.

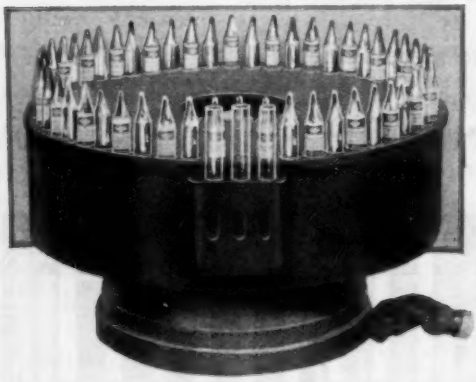

FIG. 4.—LaMotte Roulette Comparator.

The worker should, however, be warned against possible errors due to matching against the color standard on either end of any given set. Thus, a test sample may match the Bromthymol Blue standard, p_H 7.6, and yet have a much higher p_H value, due to the fact that p_H 7.6 is the end of the range of Bromthymol Blue. In such a case the test should be repeated using Phenol Red.

After a few actual determinations have been made the above procedure will be found to be very quick and simple. In fact the worker will quickly learn by experience which indicator should be used in each step of a process and can therefore make the comparison directly, without first making the rough test.

We stated above that some sort of comparator is necessary in making accurate measurements. The actual procedure can be illustrated by means of the Roulette Comparator shown in Fig. 4.

Contents of Set

The comparator consists essentially of a stationary base and metal band, and a wooden drum which revolves inside the metal band, on ball bearings. A block, which contains three slots, and which is drilled to hold three graduated test tubes, is fastened to the front of the metal band. A 40-watt Mazda lamp is fixed in the center of the base. A piece of etched glass is fixed on the front of the test tube block and a piece of Daylite glass is placed directly behind the test tubes. With this arrangement the observer always makes his readings under standard, diffused daylight conditions, so that measurements made at night or in a dark place are just as accurate as those made during the day.

The revolving drum holds three sets of color standards, for example, Chlorphenol Red, p_H 5.2–6.8; Bromthymol Blue, p_H 6.0–7.6; and Phenol Red, p_H 6.8–8.4, and 27 ampoules of distilled water. It will be noted that an ampoule of distilled water is placed between each pair of standards.

Operation of Set

Let us assume that by a rough test we have found the p_H of the solution which is being tested to be within the range of Bromthymol Blue, p_H 6.0–7.6. Fill three of the test tubes to the mark (10 cc) with the solution to be tested, and place them in the three holes in the block. Then add 0.5 cc of Bromthymol Blue indicator solution to the middle tube and shake to insure thorough mixing. Turn on the light and revolve the drum until the Bromthymol Blue color standards are directly behind the test sample. Looking toward the electric bulb through the three slots in the block, slowly shift the standards, by turning the drum, until the color through the central test tube exactly matches that of one of the tubes on either side of it, or lies between them. The p_H value can be read off directly from the color standards, as the labels on the standards project above the top of the drum. In making a reading, the drum must be turned so that an ampoule of distilled water is always in the position directly behind the central test tube to which the indicator solution has been added.

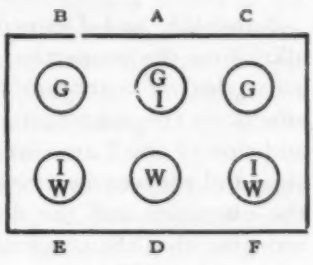

FIG. 5.

The reason for this arrangement of tubes is to eliminate any effect of color or turbidity in the sample which is being tested. For example, suppose that we are testing a turbid solution. We shall designate this turbid solution by *G*, water by *W* and the indicator solution by *I*. Referring to Fig. 5, *B*, *A*, and *C* represent the three test tubes which are filled with the

solution which is being tested. *D* represents the ampoule of distilled water, and *E* and *F* the color standards.

To make this clear, the color standards may be considered as made up of water and indicator solution. They do of course contain solutions of salts to give them definite p_H values, but, since these solutions of salts are clear and colorless, they may be considered to be made up of only these two materials.

It will be seen from Fig. 5 that each pair of tubes (*B* and *E*, *A* and *D*, *C* and *F*) contains the turbid solution *G*, indicator solution *I*, and water *W*, the only difference being that the indicator solution has been added to the turbid material in the central test tube, instead of to the distilled water tube which is placed behind it. The final combination is, however, the same in all pairs. It is therefore apparent that, when the proper color standards are in place, an exact match must be obtained, since the observer is looking through exactly the same materials in each pair of tubes. The conditions would of course be similar if the material which is being tested were colored instead of turbid.

If by the rough test it is found that the p_H value of the material lies in the range of Chlorphenol Red, the same procedure is followed, except that of course Chlorphenol Red indicator solution, instead of Bromthymol Blue, is added to the middle tube and the drum revolved until the Chlorphenol Red color standards are in position for comparison.

It will be seen that most of the indicators overlap so that it is usually possible to make determinations on the same sample with two different indicators and thus check results.

Since the indicators may be adsorbed by the clay to a greater or less degree, it is usually best to make the determinations on filtered material. The filtration can be carried out most efficiently by means of an alundum crucible.

Application to Ceramics

Randolph and Donnenwirth[1] state that the effects of acids and alkalis on the properties of clay and water mixtures have received a great deal of attention because of the important relations of these effects to the manufacture of almost every type of clay ware. The addition of small amounts of acid or alkali affects the viscosity of clay slips and the way in which they act in the casting mold, and influences the plasticity and the dry strength of the dry clay. It is generally accepted that the properties of a mixture of clay and water are largely affected by the presence of colloidal material and it is well known that the p_H of a colloidal suspension has a marked effect on its properties.

[1] "Hydrogen-Ion Measurements on Clay Slips," *Jour. Amer. Ceram. Soc.*, 9 [8], 541 (1926).

These authors state further that numerous and often contradictory results are reported in regard to the effect of acids and alkalis of different strengths on the physical properties of slips and clay pastes. Evidently the action depends on many factors, such as the original condition of the clay in regard to acid or alkali content, the concentration of the clay in the water, the time of aging of the mixture, the strength of the added electrolyte, etc. They conclude that a method for following the changes in acidity of the water portion would give information of value.

Plastic clay bodies are in the flocculated condition and casting slips, which as a rule are just on the border line, are often designated as being deflocculated. The proper working condition depends largely on the nature and amount of soluble salts present in each case and hence may be associated with a certain p_H value. Any variation will indicate the nature of the change in the clay and this can then be properly compensated for. Due to natural variation in many of the raw materials used in the clay-working industries, it is not to be expected that a plant should continue operation with its body adjusted to a definite, constant p_H value unless unusually uniform materials are being obtained. The slight variations which commonly occur may be compensated for by varying the amount or kind of flocculating or deflocculating materials used.

For best working properties of plastic bodies the p_H value as a rule will lie between 3.5 and 7.0, while for wares made by the casting process it may be between 5.5 and 9.3. Frequently in the case of cast wares made from less pure clays, such as fire clay, the optimum p_H will fall in the lower part of this range, as from 5.5 to 7.5; while for whiteware bodies, made from purer white firing clays, the optimum value will be in the upper part of the range, say from 7.5 to 9.3.

Casting scrap is merely the regular casting slip from which the water and part of the soluble salts have been extracted, and it always contains more or less of the deflocculating salts originally added to the slip. After blunging up with a definite amount of water, the relative amount of deflocculating salts present can be estimated from the p_H value. The scrap can then be mixed with the regular casting slip in constant proportions with the new body, allowance being made for the soluble deflocculating salts it already contains.

Randolph and Donnenwirth[1] conducted experiments which showed that there was a direct relationship between the viscosity of a slip made from Kentucky ball clay and the p_H of the water used in making the slip. As the p_H of the water increased the viscosity decreased. In one case the viscosity decreased from 48 at p_H 4.0 to 11 at p_H 8.0. They state that in the casting of clays the effect of slight changes in acidity or alkalinity are therefore important and that changes in H-ion concen-

[1] *Loc. cit.*

tration rather than additions of a particular electrolyte by volume may explain some of the puzzling things that occur.

These workers showed further that there is a definite relationship between dry strength and the p_H of the water phase of the system. A spark plug body showed a dry strength of 2000 or over when the p_H of the slip was between 5.7 and 6.7. The strength fell off rapidly to 1000 as the p_H of the slip was decreased to 4.7 or increased to 8.3. No difference could be detected in dry strength when adjustment to a given p_H was made by means of different electrolytes. Thus acetic and hydrochloric acids, and sodium silicate which was added to a batch which had first been made too acid by mistake, all gave products of the same dry strength when the p_H of the body was brought to the same value.

The effect of p_H on the adsorption of dyes by clays is clearly shown by the work of Thies.[1] He found that two different clays of the same chemical type did not behave similarly when compounded in rubber. One type gave good cures and high tensile strength while the other type gave slow cures and low tensile strength. He also found that these two clays had very different reactions, a suspension of the clay which gave good cures having a p_H value of 7.1, and that of the clay which gave poor cures having a p_H value of 4.0. In an attempt to differentiate between good and poor clay for rubber work, he made measurements of the adsorption of dyes by the two types of clay mentioned above. In this work he used sixteen different dyes. The adsorption of dyes by the clay which had a p_H value of 7.1 was very erratic and also very low. The average retention for the sixteen dyes was 39% of the dye added. In only four cases was the retention over 50%. On the other hand, the average retention by the clay which had a p_H value of 4.0 was 73%. In ten of the sixteen dyes the retention was over 90%, and in seven it was 99% or over.

Thies states that

> The erratic amount of adsorption exhibited by the good clay could be expected .... as the adsorption is in some way affected by the hydrogen-ion concentration; probably the different dyes at various p_H values are adsorbed in different amounts by a single clay. At least it is unlikely that the clay under investigation should offer the most favorable condition for adsorption to all dyes in all cases.

In addition to dyes, Thies also ran experiments with various rubber accelerators and found that adsorption of these materials was similar to that of the dyes. In other words, the phenomenon is apparently general.

This work, as well as that of several others on the dyeing of silk and wool, shows that, by accurate p_H control, the amount of dye ordinarily used to give a definite shade or depth of color can in most cases be

[1] *Ind. and Eng. Chem.*, **17**, 1165 (1925).

reduced. It has also been proven that this control method enables the worker to match shades in different batches with great accuracy.

Technical Discussion of the Meaning of p_H Values

According to the theory of electrolytic dissociation, all liquids of which water is a constituent contain free H- and OH-ions. When the number of H-ions exactly equals the number of OH-ions, the solution is said to be neutral. If the number of H-ions exceeds that of the OH-ions the solution is said to be acid. Conversely, if the solution contains an excess of OH-ions, it is said to be alkaline.

Strong acids are those which are highly dissociated in solution to give a large number of H-ions. Weak acids are those which are but slightly dissociated in solution and therefore give relatively few H-ions. Thus HCl and H_2SO_4 are strong acids and CH_3COOH and H_3BO_3 are weak acids.

$$\left.\begin{aligned} HCl &\rightleftarrows \overset{+}{H} + \overset{-}{Cl} \\ H_2SO_4 &\rightleftarrows 2\overset{+}{H} + \overset{=}{SO_4} \end{aligned}\right\} \text{large number of H-ions, strong acids}$$

$$\left.\begin{aligned} CH_3COOH &\rightleftarrows \overset{+}{H} + \overset{-}{CH_3COO} \\ H_3BO_3 &\rightleftarrows 3\overset{+}{H} + \overset{\equiv}{BO_3} \end{aligned}\right\} \text{small number of H-ions, weak acids}$$

In other words it is the concentration of H-ions in a solution which determines the strength of an acid. In titration, 10 cc of $N/10$ HCl and 10 cc of $N/10$ acetic acid will of course each require 10 cc of $N/10$ NaOH for neutralization. The number of H-ions in $N/10$ HCl is, however, almost 70 times as great as the number of H-ions in $N/10$ CH_3COOH. It is, therefore, readily seen that the H-ion concentration is not determined by simple titration. It has been conclusively proved that H-ion concentration and not total acidity is the controlling factor in the majority of chemical reactions. The importance of making p_H determinations is therefore apparent.

Pure distilled water will conduct an electric current to a very slight degree. This shows that a very small proportion of the water is dissociated into H- and OH-ions. By the mass law

$$\frac{\text{Concentration of H-ions} \times \text{Concn. of OH-ions}}{\text{Concentration of undissociated } H_2O} = \text{a Constant}$$

Since the amount of undissociated water is relatively extremely large, it can be taken as a constant, and the above equation, therefore, becomes

$$\text{Concn. of H-ions} \times \text{Concn. of OH-ions} = \text{a Constant}$$

By electrical conductivity measurements, this constant has been found to be 1/100,000,000,000,000 or 10^{-14} at 21°C. Since in pure distilled water the number of H-ions is equal to the number of OH-ions, each must have a concentration of 1/10,000,000 or 10^{-7}.

This method of expressing H-ion concentration is very inconvenient and clumsy. Sorensen, therefore, suggested the use of the term "p_H," the p_H value being the logarithm of the reciprocal of the hydrogen-ion concentration. Thus

$$p_H = \log \frac{1}{(H+)}$$

in which (H+) represents the concentration of H-ions in grams per liter.

Just as an acid solution is said to be normal when it contains 1 g of *ionizable* hydrogen per liter, so a solution is said to be normal with respect to hydrogen ions when it contains 1 g of *ionized* hydrogen per liter. Since $\frac{1}{H(+)}$ is reciprocal the normality of H-ions in a solution, the p_H value can also be defined as the logarithm of the denominator expressing the normality of H-ions such as $N/10$, $N/100$, $N/1000$, etc.

This method of expressing H-ion concentration has now been generally adopted. In the case of pure distilled water, in which the H-ion concentration is 0.0000001 grams per liter or $N/10{,}000{,}000$, the p_H value would therefore be the log of 1/0.0000001 or of 10,000,000, which is 7.0. This value 7.0 is, therefore, the neutral point on the p_H scale.

It will readily be seen that p_H values below 7.0, such as 6.0, 5.0, etc., will denote acidity, the degree of acidity increasing as the numbers decrease. For example, if a small amount of HCl is added to pure distilled water which has an H-ion concentration of 10^{-7}, or a p_H value of 7.0, the acid will dissociate into positive H-ions and negative Cl-ions. The total number of H-ions in the solution will therefore be greater than 10^{-7}, and the solution will therefore be acid. Suppose the H-ion concentration is found to be $N/1{,}000{,}000$. The p_H value will be the log of 1,000,000 which is 6.0. Similarly, if the H-ion concentration is $N/100{,}000$, the p_H will be 5.0, etc. It should be remembered that, since we are dealing with logarithmic values, a solution having a p_H value of 6.0 contains 10 times as many H-ions as one having a p_H value of 7.0. Similarly, a solution of p_H 5.0 contains 100 times as many H-ions as one of p_H 7.0.

Since by the law of mass action

Concn. of H-ions×Concn. of OH-ions=a Constant

it is apparent that as the H-ion concentration increases the OH-ion concentration must decrease, and vice versa. Even in a strongly alkaline solution there are, however, some H-ions and, for the sake of simplicity, it is advisable to express both acidity and alkalinity in terms of p_H values.

From the fact that neutral water has an H-ion concentration of $N/10{,}000{,}000$, it is apparent that an alkaline solution must contain a smaller number of H-ions. Let us assume that, by adding a small amount of sodium hydroxide to pure water, we decrease the H-ion concentration to $N/100{,}000{,}000$. The p_H value of this solution would be 8.0. Similarly, if the H-ion concentration is reduced to $N/1{,}000{,}000{,}000$, the p_H value would be 9.0. This shows why all values higher than 7.0 indicate alkalinity, the degree of alkalinity increasing as the numbers increase. It should be remembered here also that a solution of p_H 9.0 contains ten times as many OH-ions as one of p_H 8.0, etc.

The exact meaning of H-ion concentration and p_H values, and the derivation of the latter, can be made clear by a few concrete examples. An $N/10$ solution of hydrochloric acid is one which contains 3.65 g of HCl or 0.1 g. of ionizable H per liter. Electrical conductivity measurements have shown that at 18°C, 91.4% of the HCl is dissociated. This means that 91.4 molecules out of every 100 do not exist as molecules, but are split up into H- and Cl-ions. The remaining 8.6% of course exists as molecules. If the HCl were completely ionized, the $N/10$ solution would contain 0.1 g of H-ions per liter. Since, however, only 91.4% is ionized, it contains $0.1 \times \frac{91.4}{100} = 0.0914$ g of H-ions per liter. The normality of this solution with respect to H-ions is $\frac{1}{0.0914} = N/10.94$. The p_H value of $N/10$ hydrochloric acid is, therefore, the logarithm of 10.94 or 1.04.

An $N/10$ solution of acetic acid also contains 0.1 g of ionizable H. Electrical conductivity measurements show, however, that at 18°C it is dissociated only to the extent of 1.36%. Hence the hydrogen-ion concentration is $0.1 \times \frac{1.36}{100} = 0.00136$ g per liter. This is equivalent to an $N/735$ solution of H-ions. The p_H value of $N/10$ acetic acid is therefore the log of 735, which is 2.86.

Since the hydrogen-ion concentration of $N/10$ HCl is 0.0914 g per liter and that of $N/10$ acetic acid is 0.00136 g per liter, the hydrochloric acid contains almost 70 times as many hydrogen-ions as the acetic acid.

Acids	p_H value	Bases	p_H value
HCl	1.0	$C_6H_5NH_2$	7.8
H_3PO_4	1.5	$NaHCO_3$	8.4
CH_3COOH	2.9	$Na_2B_4O_7$	9.2
H_2CO_3	3.8	NH_4OH	11.3
H_3BO_3	5.2	Na_2CO_3	11.6
C_6H_5OH	6.0	NaOH	13.1

The above table will give the worker some idea of the relationship between the total acidity and p_H value of a few common acids and bases. The p_H values have been given for $N/10$ solutions and are rounded off to the nearest 0.1, as this is sufficiently accurate for general

work. Thus, the above value for acetic acid, p_H 2.86, is given as 2.9 in the table.

Buffer Action

It is clear from the above discussion that, if the solutions which are encountered in chemical processes, bacteriological and pathological work, etc., were only solutions of known pure acids and alkalis, the p_H value could be calculated from the titration values and ionization constants. This is, however, seldom the case, as the solutions normally contain relatively indefinite quantities of other substances, and usually a number of unknown impurities. Many, and in fact, most of these solutions have what is known as "buffer action," which means that considerable quantities of acid or alkali can be added to them without changing their p_H value. This action can best be illustrated by means of an example. Pure water, as stated above, has a p_H value of 7.0. If 1 cc of 0.01 *N* HCl is added to a liter of pure water, the p_H value will be changed to about 5.0. Let us now consider a solution containing a mixture of sodium acetate and acetic acid. In this solution the dissociation of the acetic acid is very small

$$CH_3COOH \rightleftharpoons CH_3\bar{C}OO + \overset{+}{H}$$

The dissociation of sodium acetate is, however, large

$$CH_3COONa \rightleftharpoons CH_3\bar{C}OO + \overset{+}{Na}$$

Now suppose we add a small quantity of HCl to this solution. It is immediately largely dissociated into H and Cl ions.

$$HCl \rightleftharpoons \overset{+}{H} + \bar{Cl}$$

We therefore have in solution H, Cl, Na, and CH_3COO ions. Acetic acid ionizes only to a very slight degree. This means that CH_3COO and H-ions cannot exist together in solution to a very large extent. Therefore, the larger part of the H-ions from the HCl will immediately combine with CH_3COO-ions to form undissociated molecules of acetic acid, and the H-ion concentration or p_H value of the solution will be only very slightly changed, if at all. The HCl which was added would of course be shown by titration. If, on the other hand, NaOH is added to this mixture, it will react with the H-ions to form Na-ions and H_2O. More acetic acid will then dissociate into CH_3COO and H-ions and the H-ion concentration will be practically the same as it was before. It will, therefore, be seen that considerable quantities of acids or alkalis may be added to solutions containing buffer salts without changing the p_H value. Since this is true, it is clear that

buffered solutions can be diluted with distilled water, even though the water shows a very acid reaction, without affecting the p_H value. In fact, some solutions can be diluted as much as 1000 to 1. This is of importance in making determinations on very highly colored and turbid solutions.

In general the salt of any weak acid or weak base is a buffer salt. There are, therefore, very few solutions which are free from buffer action. For example, the phosphates in raw sugar and culture media, carbonates in raw water, carbonates and silicates in clay work, etc., have buffer action.

The figures in the following table will bring out the importance of making p_H determinations rather than determining the total acidity or alkalinity by titration. These figures are actual determinations made on liquors in a sugar refinery:

Per cent acidity by titration	p_H values	Per cent alkalinity by titration	p_H values
0.001	6.5	0.001	8.3
0.010	6.4	0.003	7.3
0.005	5.3		
0.005	7.0		

In the first pair of figures, the acidity of the second liquor is just ten times that of the first one, as determined by titration. The p_H values of the two are, however, practically the same. In the second pair of figures both have an acidity by titration of 0.005%, while the p_H values show the acidity of the first to be almost 100 times greater than that of the second. The third pair of figures shows even greater discrepancy. By titration the second solution is three times as alkaline as the first. By p_H measurements, however, the first is ten times as alkaline as the second. While these figures represent measurements on sugar liquors, solutions from other processes show similar errors.

Unbuffered Solutions

From the above discussion it will be realized that no special precautions are necessary in making p_H measurements on buffered solutions, since the addition of considerable amounts of acid or alkali can be made without affecting their p_H value.

Such is not, however, the case with distilled water or with unbuffered solutions, especially when their p_H value is near the neutral point 7.0. The fact that distilled water is one of the most difficult materials to test for p_H is frequently overlooked. This is due to the fact that it is absolutely devoid of any buffering action, and is thus very susceptible to change during the test, for example, by the absorption of carbon dioxide, etc.

Pure distilled water has a p_H value of 7.0 at 18°C. The reaction of ordinary distilled water is, however, always acid, because of the absorption of carbon dioxide. Water which has taken up carbon dioxide from the air until equilibrium has been established, will contain about 0.3% of CO_2 by volume, and the calculated p_H should be 5.7. In fact, this is the value which is usually found in distilled water which has been freely exposed to pure air. Water from an efficient automatic still, when stored in closed nonsoluble glass vessels, will have a p_H of 6.0 to 6.4. If this water is boiled for a short time in a Pyrex vessel, and the vessel then fitted with a soda lime tube, it will usually have a p_H of 6.6 to 6.8.

When it is necessary to make a solution or suspension of an unbuffered material in order to determine its p_H value, the water used should of course be as nearly neutral as possible, as any acidity of the water will affect the p_H of the dissolved material. Water having a p_H value of 6.6 to 6.8 is usually satisfactory for this work. In making these solutions, the proportion of material to water should always be kept the same, so that different determinations will be comparable; for example, 10 g of material to 50 cc of water. It is of course equally true that the indicator solutions should have a neutral reaction, since any excess acid or alkali will likewise change the p_H value of the material.

These precautions are particularly important when the p_H value of the material is near 7.0. Around this point small variations in hydrogen-ion concentration, due to absorption of carbon dioxide, etc., have a marked effect on the p_H value. This effect is of course much less marked when we get below 6.0 or above 8.0.

In making a test on distilled water or unbuffered solutions, the indicator and the material being tested should always be mixed in the test tube by means of a stirring rod, with the minimum of exposure to air, and readings should be made at once. If this is done, reliable results will be secured with the colorimetric method. In fact, this is the only way in which such solutions can be tested for p_H, since electrometric methods are very unreliable when applied to most unbuffered solutions.

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A METHOD FOR MEASURING THE SOFTENING TEMPERATURE OF GLASSES[1]

By J. T. Littleton, Jr.

ABSTRACT

For the purpose of measurement the softening point of glasses is defined as that temperature at which a uniform thread of glass .65 mm to 1 mm in diameter suspended in a vertical position in an electric furnace of specified characteristic will elongate at the rate of 1 mm per minute. The measurements on a given glass are reproducible to within 1 to 2°C. This method has been found useful as control of glass composition in melting units as well as a point of reference to distinguish between different glasses. Data are given showing the variation in softening point of a tank glass and a pot glass over an interval of time.

Introduction

Uniformity of product is desired in all industries and particularly so in the glass industry where the articles are made on automatic machines and may be later subjected to a second automatic operation. In order to obtain the desired degree of uniformity, some method of measurement is necessary for the control of the batch. The property of the material measured for control purposes should be a property which affects the operation of the machine. The requirements of a control method are that it shall be sufficiently simple so that a number of measurements can be made, and the measurements shall have a sensitivity sufficient to detect any variations before any change is noticeable in the ware or in the fabrication of the ware. The property of the glass which most directly affects the operation of the automatic machines is the viscosity. The timing of the machine is adjusted for a certain viscosity and it is necessary for this property to remain constant in order that the machine function uniformly. In operation constant viscosity is sought by means of temperature control. This assumes that the glass remains constant in composition.

Description of Method

The following is a description of the method which has been used at the Corning Glass Works for a number of years as a control of the the composition. The method consists in measuring the temperature of the glass at which it has a certain viscosity, which temperature is called the softening point of the glass. The method described here was not originated at Corning but it is believed to have been first used by the Jena Glass Works though there seems to have been no written description of it on record. It is believed that in addition to serving as a method for control it further furnishes a point of reference to indicate difference between different glasses of different composition in regard to viscosity.

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (Glass Division). Received Jan. 18, 1927.

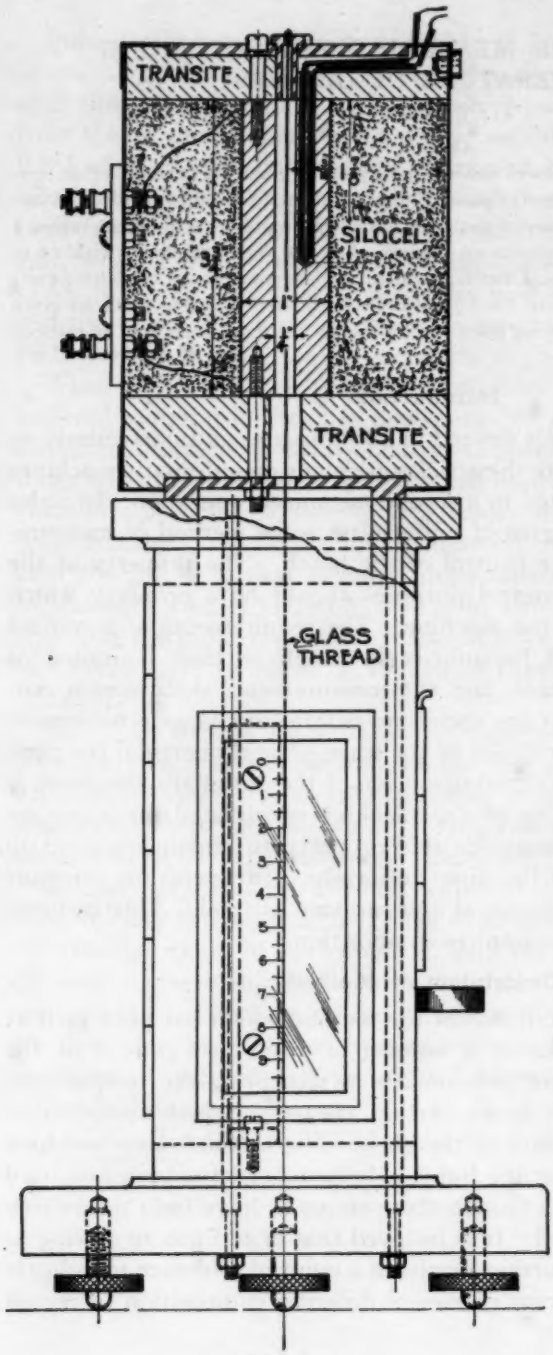

FIG. 1.

Experimental Method

The softening point of glass may be defined as that temperature at which a uniform thread of glass of standard length (22.9 cm) elongates under its own weight at the rate of one millimeter per minute when suspended in a furnace. It is evident that this method gives only an approximately accurate comparison between glasses of widely different compositions since surface tension and specific gravity both enter to affect the force tending to elongate the specimen. However, since the viscosity at these temperatures, changes by a factor of two for about each 15°C change in temperature, it is apparent that there will need to be considerable difference in these properties to materially affect the comparison. In order to have results reproducible within the desired degree of accuracy close adherence to the details of the construction of the furnace and to the procedure of making the measurements is necessary. The furnace construction is shown in the drawing.

The metal core is insulated with mica and wound with nichrome ribbon or wire. The distribution of temperature along this core is found to vary with the age of the furnace. The procedure is as follows:

A uniform thread of glass from .65 mm to 1 mm in diameter, 22.9 cm long is worked to this shape in a flame avoiding crystallization or reduction. The thread should not vary in diameter along its length by more than .05 mm. The bottom of the thread is formed to a needle point about 1 mm long and bent at right angles to the length to serve as a pointer indicating its position on a scale or it may be merely rounded off. This thread is suspended from one end in the electric furnace shown in the drawing (Fig. 1) at any temperature from 50 to 100°C below the softening point of the glass being tested and the furnace temperature then raised uniformly at a rate of 5–10°C per minute. The position of the end of the glass thread is noted on the millimeter scale every thirty seconds. Immediately after noting the position of the point the temperature of the furnace as indicated by the thermocouple mounted with its junction at the center of the

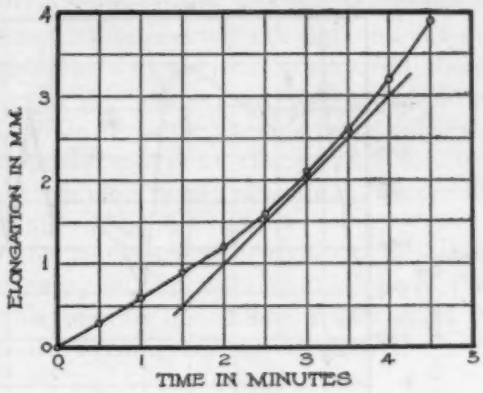

FIG. 2.

TABLE I

Time Min.	Sec.	Temperature °C	Elongation mm
0	:00		0.0
	15	680	
	30		0.3
	45	682	
1	:00		0.6
1	15	684	
1	30		0.9
1	45	686	
2	:00		1.2
2	15	688	
2	30		1.6
2	45	690	
3	:00		2.1
3	15	692	
3	30		2.6
3	45	695	
4	:00		3.2
4	15	697	
4	30		3.9

Softening point, 691 °C.

furnace is read. A curve is plotted between time and position of the point on the scale, using ten divisions on the paper for 1 mm on the scale and ten divisions on the paper for one minute. Hence the tangent to the curve having a 45° slope will indicate that point on the curve at which the rod is elongating at the rate of 1 mm per minute. Comparison of the time at which the glass was elongating at this rate with the temperature-time observations will then give the temperature required

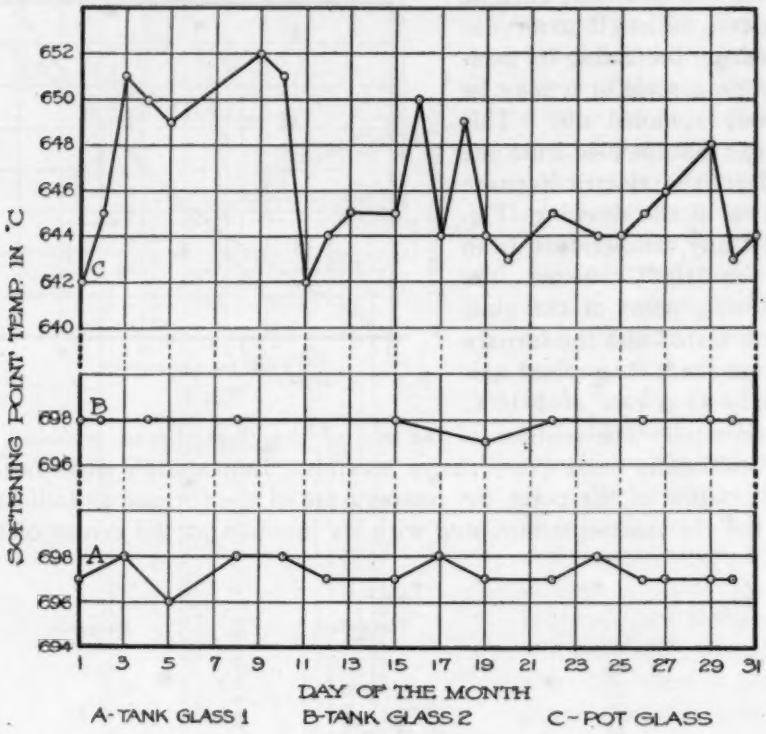

FIG. 3.

to obtain this degree of softness. Such a curve obtained in such a manner is given in Fig. 2 and the data from which the curve is obtained is found in the table.

The position of the point may be noted by means of a telescope or by means of a reflector mounted back of this scale; either of these means will serve to avoid parallax. Measurements repeated on the same glass should be reproducible to within at least 2°C and with care a 1°C accuracy can be attained.

Attention has been called to the fact that the temperature distribution in the furnace may change. This is corrected for by means of check

runs on a standard glass which necessitates a stock of standard glass. Check measurements should be made with considerable frequency. The data being obtained on the glasses being tested are corrected on the basis of the measurements on the standard glass. The curves given in Fig. 3 show the variations in two tanks from which daily measurements are made and also the variations in a pot glass.

It is realized that measurements at these temperatures are not a measure of the viscosity at melting temperatures, and that it is possible for a variation to enter in the melting temperature of the tank and at the machine without being observable at the temperatures of these tests. Variation of two degrees at this temperature corresponds to a viscosity change of about 15%, while at the tank temperature a change of about 6°C causes approximately the same change in viscosity. Measurements at these temperatures more nearly measure the condition that exists when the glass is being worked in a flame.

Experience has shown that this test made systematically furnishes a satisfactory control for uniformity of composition. The use of the temperature determined in this manner for different glasses as a physical constant has proved useful to compare different glasses.

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THE PARTICLE SIZE DISTRIBUTION OF TYPICAL FELDSPARS AND FLINTS[1]

By Edward Schramm and E. W. Scripture, Jr.

ABSTRACT

The results of particle size analyses of a number of commercial feldspars and flints by the sedimentation method are reported. A comparison of batch and continuous grinding is given as well as a study of the progress of ball mill grinding.

In a paper on "The Particle Analysis of Clays by Sedimentation"[2] the authors described a simple method of size analysis applicable to fine-grained materials. This method was found well adapted to the study of feldspars and flints beyond the limit of the finest screen. Since ceramic materials in general are ground so that the bulk passes the finest testing sieve, it is obvious that an analysis beyond this range is necessary to make possible comparisons between different materials and between various methods of grinding. Pressler and Shearer[3] give data for various flints obtained by the method of air elutriation. This method does not appear adequate for a classification of the finest sizes and requires special apparatus and technique, whereas the sedimentation method is easily available to any laboratory.

In Table I are given the analyses of a number of commercial feldspars and flints.

The screen tests reported were carried out on a separate sample of 250 g and the sedimentation test made on material which passed the 325-mesh screen, the results being finally calculated to percentage of the original material.

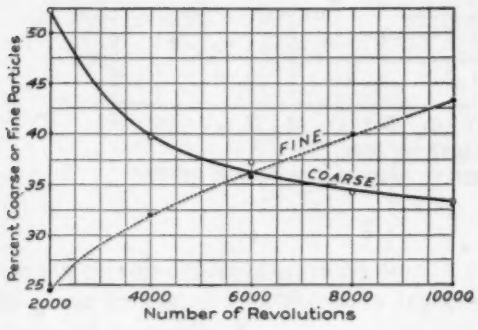

FIG. 1.

To aid in comparing the different materials, we have grouped the percentages into three size ranges—large (over 8.3μ); intermediate (8.3–2.5μ); small (below 2.5μ). The lower limit of our large size group is about one-third the opening of the 325-mesh screen. The sand flint is ground in a continuous tube mill; rock flint and feldspar A in batch

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (White Wares Division.) Received January 14, 1927.

[2] E. Schramm and E. W. Scripture, Jr., *Jour. Amer. Ceram. Soc.*, 8 [4], 243–52 (1925).

[3] Bur. Stand., *Tech. Paper*, No. 310.

TABLE I

Radius μ	Standard screen	Sand flint	Rock flint	Feldspars A	B	C	D	E
Over 73.5	100	.04	.10	0.25	0.03	0.12	0.08	0.13
73.5—52.0	150	.10	.34	0.44	0.06	0.32	0.22	0.19
52.0—37.0	200	.32	1.00	1.33	0.19	0.73	0.42	0.32
37.0—30.5	250	.94	1.20	2.28	0.63	1.30	1.96	0.51
30.5—22.0	325	2.64	6.28	6.08	5.32	5.79	5.10	9.19
22.0—14.3		16.5	11.5	9.7	11.2	17.8	18.4	8.1
14.3—10.3		9.4	17.8	11.8	17.6	17.8	23.0	23.8
10.3— 8.3		8.6	7.6	6.4	6.2	9.2	6.5	8.9
8.3— 7.2		5.7	4.9	6.3	5.3	3.7	2.3	4.2
7.2— 5.9		10.1	8.4	3.8	7.1	3.1	9.9	4.9
5.9— 5.1		6.3	4.4	2.8	5.1	1.7	4.8	2.8
5.1— 4.1		1.0	5.5	7.2	5.4	4.9	2.9	10.2
4.1— 3.2		4.5	4.0	4.3	4.3	7.0	4.1	4.8
3.2— 2.8		7.4	5.8	4.2	3.8	2.6	5.0	2.0
2.8— 2.5		3.8	3.6	4.8	2.1	2.0	1.7	0.4
2.5— 2.3		1.3	2.6	3.4	1.1	0.9	1.1	0.4
2.3— 2.0		5.0	3.6	1.3	1.9	2.4	0.6	2.7
2.0— 1.85		1.6	1.4	1.0	1.2	1.1	0.6	3.4
1.85— 1.7		2.2	0.9	1.9	1.2	3.0	2.1	1.6
Below 1.7		12.5	9.1	20.8	20.2	14.6	9.1	11.5
		99.94	100.02	100.08	99.93	100.06	99.98	100.04
Over 8.3		38.6	45.8	38.3	41.3	53.0	55.7	51.4
8.3— 2.5		38.8	36.6	33.3	33.1	25.0	30.7	29.0
Below 2.5		22.6	17.6	28.4	25.6	22.0	13.6	19.6

mills; feldspar B in single Hardinge mill with air separator operated to give maximum production of fines; feldspar C in tandem Hardinge mills with air separator, and D and E in Hardinge mill, tube mill, air separator plant. The above represent standard commercial materials. The batch ground feldspar A gives higher rejections on the screens (especially the coarser ones) but in the ultimate analysis shows a larger proportion of fines.

Through the coöperation of the producer of feldspar C, we were enabled to carry out a comparison of the results of batch and continuous grinding of the same material. The batch grinding was carried out by us in a 7-foot diameter mill with the level of pebbles alone 40% of the inside diameter of the mill; the level of pebbles plus 2½ tons of crushed unground feldspar about 50% of the diameter. The rock feld-spar was crushed on a chaser mill and screened through a 16-mesh screen before feeding to the ball mill. It will be seen that our ball mill feed is finer than is customary in commercial operation. The ball mill was run for five hours (5500 revolutions). The results of this run are given below in comparison with the data for the same feldspar continuous ground.

It will be noted that the total rejection on 250-mesh for the continuous ground feldspar is 2.47%, for the batch ground 3.73%, but that the true percentages of fines are in reverse order to the indications of the screens.

TABLE II

CONTINUOUS VS. BATCH GRINDING

Radius μ	Standard Screen	Continuous	Batch
Over 73.5	100	0.12	1.07
73.5 —52.0	150	0.32	0.70
52.0 —37.0	200	0.73	0.89
37.0 —30.5	250	1.30	1.07
30.5 —22.0	325	5.79	3.29
22.0 —14.3		17.8	12.5
14.3 —10.3		17.8	11.0
10.3 — 8.3		9.2	3.7
8.3 — 7.2		3.7	1.5
7.2 — 5.9		3.1	3.2
5.9 — 5.1		1.7	3.0
5.1 — 4.1		4.9	5.2
4.1 — 3.2		7.0	7.8
3.2 — 2.8		2.6	3.7
2.8 — 2.5		2.0	2.0
2.5 — 2.3		0.9	1.7
2.3 — 2.0		2.4	3.2
2.0 — 1.85		1.1	3.3
1.85— 1.7		3.0	5.0
Below 1.7		14.6	26.2
		100.06	99.93
Over 8.3		53.0	34.3
8.3 — 2.5		25.0	26.3
Below 2.5		22.0	39.4

To follow more closely the operation of batch grinding, we ground a charge of high potash Canadian feldspar in our 7-foot ball mill withdrawing samples after each 2000 revolutions up to 10,000 (9 hours grinding). The screen analysis of the material as it entered the ball mill was as follows:

Standard screen	8	14	28	48	65	100	150	200	250	325
Per cent rejection	.04	.36	7.52	23.72	8.64	9.08	9.75	5.64	1.72	4.96
Total on 325										71.43

The particle analyses of the ground samples are given in Table III.

In the curves, Fig. 1, we have plotted the per cent coarse (over 8.3μ) and the per cent fines (below 2.5μ) against the number of revolutions. It is evident that as the grinding proceeds the work accomplished per revolution becomes progressively less.

The continuous systems with air separation are most efficient in producing material to pass the screens; batch ground material of the same screen test has a smaller average particle size. We should therefore expect greater fluxing power from the latter. This was shown in a comparison of the samples described in Table II. Cones were made of the feldspars alone and of cone 4 mixes using the two feldspars but otherwise identical materials. A number of these were set alternately in bats and fired in a gas furnace. In all cases greater deformation was ob-

TABLE III

PROCESS OF GRINDING IN BALL MILL

Radius μ	Standard Screen	Number of Revolutions 2000	4000	6000	8000	10,000
Over 73.5	100	1.64	0.57	0.63	0.55	0.38
73.5 —52.0	150	6.07	1.90	1.33	1.13	0.88
52.0 —37.0	200	6.07	2.85	2.40	1.95	1.64
37.0 —30.5	250	3.29	1.77	2.21	1.70	1.77
30.5 —22.0	325	7.73	6.20	5.26	4.67	4.75
22.0 —14.3		12.5	11.3	12.2	11.7	9.1
14.3 —10.3		8.9	9.0	9.3	10.3	10.0
10.3 — 8.3		5.9	6.0	3.9	2.2	4.7
8.3 — 7.2		2.6	2.2	3.8	1.8	2.8
7.2 — 5.9		2.4	2.9	3.9	2.9	4.3
5.9 — 5.1		3.0	4.0	5.4	7.9	7.0
5.1 — 4.1		5.0	7.3	7.0	6.9	4.8
4.1 — 3.2		3.0	4.5	3.8	3.4	2.4
3.2 — 2.8		4.1	4.2	1.9	1.7	1.9
2.8 — 2.5		3.2	1.6	1.2	1.2	1.5
2.5 — 2.3		3.2	1.7	1.2	1.2	1.3
2.3 — 2.0		0.8	2.8	2.3	1.1	3.3
2.0 — 1.85		1.1	3.0	1.9	3.1	3.6
1.85— 1.70		3.2	3.3	4.8	6.4	5.4
Below 1.70		16.3	23.0	25.6	28.2	28.6
		100.00	100.09	100.03	100.00	100.12
Over 8.3		52.1	39.7	37.2	34.2	33.3
8.3 to 2.5		23.3	28.2	27.0	25.8	23.5
Below 2.5		24.6	32.1	35.8	40.0	43.2

tained with the batch feldspar, although if we were to judge by residue on the 250-mesh screen, this would be the coarser of the two materials. Similar results were obtained with the samples representing the progress of ball mill grinding (Table III), the deformation of feldspar alone and of cone 4 mixes increasing with longer grinding.

In presenting these results we do not intend to condemn the operation of continuous grinding mills. Beyond question, these are more economical to operate, and produce a usable material at lower cost than batch mills. A small increase in the quantity of feldspar used in a body may compensate for the larger average particle size.

The above results indicate the insufficiency and sometimes misleading character of screen tests as applied to fine ground ceramic materials, and demonstrate the advantage of carrying the analysis beyond the range of the screens.

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LOW FIRE GLAZES USING RUTILE[1]

By Myrtle M. French and Chas. M. Harder

ABSTRACT

A very fusible glaze containing rutile was fired at cones varying from 010 to 03. The fusibility was adjusted by introducing feldspar, and various colorants were added to control the color. The results were very interesting and varied—especially for a modeled or incised pattern.

$$\text{I} \quad \text{PbO } 1 \quad \begin{cases} SiO_2 & 1.62 \\ TiO_2 & .2 \end{cases}$$

Tests of above glaze, using oxides of cobalt, copper, manganese, uranium and iron, as colorants, were fired to cones 010, 09, 04, and 03. The 010 and 09 tests produced a dull matt surface; 04 and 03 went bright and showed evidence of rutile crystals at the foot of each piece. This suggested the problem of a semimatt glaze having rutile crystals, and which would mature at cones 04–03.

Feldspar was introduced to check fluidity and rutile raised to 03 giving the formula:

$$\text{II} \quad \begin{cases} PbO & .86 \\ K_2O & .05 \\ CuO & .09 \end{cases} \quad Al_2O_3 .10 \quad \begin{cases} SiO_2 1.8 \\ TiO_2 .3 \end{cases}$$

At cones 09–08 this produced an olive green matt of fair texture; at 04–03 a bright green matt of a different texture, highly fluid, but interesting in its color formation of vertical stripes, alternating in yellow, brown, and green.

Using formula II as a basis, and varying alumina and silica, the following glazes were prepared.

Batch Weights

	White lead	Canadian feldspar	Kaolin	Flint	Rutile	Colorants
II *a*	216.72	37.32	9.03	68.7	22.8	7.9 copper
II *b*	237.36	43.5	—	44.3	22.8	.9 cobalt
II *c*	237.36	37.32	6.45	51.24	22.8	14.5 yellow uranium
II *d*	201.56	49.76	5.16	61.19	22.8	16. iron
II *e*	239.94	37.32	9.	70.	22.8	2. manganese carbonate 4. uranium
II *f*	232.2	49.8	—	49.5	22.8	16. pink base

At cones 09–08 these gave good matts in dull mottled colors. At cones 04–03 the rutile crystals formed in stripes, the color depending upon the oxide used. All were matts or semimatts with occasional bright spots.

II*a* Green matt with light and dark stripes.

II*b* Light blue matt, yellow and brown stripes.

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (Art Division.) Received January 13, 1927.

II*c* Orange matt, brown and yellow stripes.
II*d* Brown matt, yellow crystals.
II*e* Light tan matt, dark brown and yellow stripes.
II*f* Cream matt, dark stripes.

These glazes give an interesting variety of colors and textures, and will fit a "Monmouth clay" body modified with 10–20% flint.

They are especially good when ground from 30 to 40 minutes, and applied to pieces having incised or modeled decorations.

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SOME EFFECTS OF VARYING SODA AND BORIC OXIDES IN GROUND COAT ENAMELS[1]

By R. R. Fusselbaugh

ABSTRACT

Variations were made from 5 to 25 % in soda oxide and boric oxide content of a given ground coat enamel, and results observed on trial pieces. It was found that an increase of soda oxide at the expense of boric oxide decreased the tendency of the enamels to blister and fishscale, and increased the tendency toward the formation of copperheads. Conversely, the increase of boric oxide at the expense of soda oxide increased the tendency of the enamels to blister and fishscale, but decreased the tendency to copperhead.

Introduction

The original purpose of this investigation was to determine the effect produced by varying the boric oxide and soda oxide contents of a particular type of ground coat enamel.

The investigation disclosed the fact that this type of enamel was prone to blister if the boric oxide content was higher than that of the soda oxide, the size and quantity of the blisters being affected by the thickness of the enamel, the blisters being larger in size and quantity in the heavier coats.

A study of the melted compositions and the results obtained from a number of ground coat enamels indicated that a possible relation existed between the boric oxide and soda oxide contents, which would produce blistering. Suspicion was directed at those enamels in which the boric oxide content was greater than the soda oxide content.

To confirm these observations, it was decided to study the effects produced upon an enamel by varying the boric and soda oxide contents.

The Experiments

A ground coat in use at the time was considered a good type to use as it would blister if it were not carefully manipulated.

In order to produce decisive results, radical changes were made. The total of soda and boric oxides in the formula to be tried was 30%. Three enamels were made with these variations:

No. I	5 %	soda	oxide—	25 %	boric	oxide
" II	15 %	"	"	—15 %	"	"
" III	25 %	"	"	— 5 %	"	"

The enamels had the following melted compositions:

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (Enamel Division.) Received January 17, 1927.

	I	II	III
Feldspar	45.4	45.4	45.4
Silica	15.0	15.0	15.0
Cryolite	7.5	7.5	7.5
Cobalt oxide	.9	.9	.9
Manganese oxide	1.2	1.2	1.2
Soda oxide	5.0	15.0	25.0
Boric oxide	25.0	15.0	5.0
	100.0	100.0	100.0
Cubical coef. of expansion	248×10^{-7}	347×10^{-7}	446×10^{-7}

No difference was noted in the smelting qualities.
The mill charge was as follows:

50.00 lbs.	glass
3.00 "	clay
2.50 "	flint
0.50 "	borax
0.20 "	soda ash
23.00 "	water

Milling Particular attention was paid to the milling of these enamels. The milling was done on one mill, one enamel being milled on each day, for three succeeding days. Each enamel was milled for twelve hours and immediately removed from the mill and the mill thoroughly washed before the next charge was placed in it.

Aging As approximately forty-eight hours had elapsed between the time the first enamel had been removed from the mill and the time the last had been removed, the enamels were not equally aged and comparable tests could not be made. In order to obtain more comparable conditions, the enamels were allowed to age for one week and the trials were made.

Trial Pieces As it was essential to have all conditions as constant as possible, the trial pieces were all cut from the same sheet of iron and numbered in the upper left hand corner in the manner shown on the accompanying chart. (See page following.)

All of the trial pieces received the same pickling treatment.

Amount of Enamel per Piece The use of a standard plate for the setting of enamel has been recommended extensively and has been used successfully for some time. This method consists of dipping a standard size plate in the enamel, allowing it to drain and weighing the plate and enamel, deducting the weight of the plate and obtaining the weight of enamel on the plate. The weight of the enamel required for best results was determined by experiment and practice. The weights used for the trials in this investigation were as follows:

Heavy	0.14 lbs. wet enamel per sq. ft.
Medium	0.11 " " " " " "
Thin	0.08 " " " " " "

Firing The firing of these trials was done at a temperature of 1600°F. The heavy trials were fired 4½ minutes, the medium 3 minutes, and the thin 2½ minutes. The grate was hot when the trials were placed on it for firing.

Results

After firing the appearance of the trials was as follows:

No. I Enamel

Plate No. 10 Heavy This enamel burned a light blue or blue gray in color. Fishscale developed as soon as the plate was cool and after three days it was badly fishscaled. The fishscale ruptures were in size from very minute to a quarter of an inch across, most of the smaller ruptures occurring on the back of the plate.

Plate No. 40 Medium This trial is similar in color to the above trial, the color being slightly darker. It is covered on both sides with a medium sized fishscale.

Plate No. 70 Thin The color of the enamel on this plate is similar to that of the enamel on the other two plates in this enamel, except that it has a brownish hue, due to its transparency. It is almost entirely covered on both sides with a very small fishscale. There is no tendency for the enamel to "burn out," although the enamel is quite thin.

10 No. I Enamel Heavy 25% B_2O_3 5% Na_2O Blistered Fishscaled	40 No. I Enamel Medium 25% B_2O_3 5% Na_2O Blistered Fishscaled	70 No. I Enamel Thin 25% B_2O_3 5% Na_2O Blistered Fishscaled
20 No. II Enamel Heavy 15% B_2O_3 15% Na_2O Blistered	50 No. II Enamel Medium 15% B_2O_3 15% Na_2O No blisters	80 No. II Enamel Thin 15% B_2O_3 15% Na_2O No blisters
30 No. III Enamel Heavy 5% B_2O_3 25% Na_2O Blistered where heavy Pitted and spotted	60 No. III Enamel Medium 5% B_2O_3 25% Na_2O No blisters Badly spotted	90 No. III Enamel Thin 5% B_2O_3 25% Na_2O No blisters Badly burned out

No. II Enamel

Plate No. 20 Heavy This trial is typical of heavy blue ground coat enamel and does not show any defects.

Plate No. 50 Medium This trial is very good. A dark blue enamel, burning to a greenish tint where thin; it is well covered, has a smooth surface, and does not show any defects.

Plate No. 80 Thin This trial is exceptionally good. Enamel is thin, burned to a blue-green color and does not show any defects.

No. III Enamel

Plate No. 30 Heavy The enamel on this trial burned to a dark blue-green in color and has a very glossy finish. It is very much pitted, the pits being similar to those produced in ground coat by the crystallization of borax. Although the enamel is heavy, rust spots burned thruogh from the iron in the characteristic copper-head form and the enamel is burned away from the edges.

Plate No. 60 Medium The enamel on this plate is badly burned out in the form of rust spots or copperheads and is not a complete burning out of the enamel. The spots are larger than are usually encountered in this type of defect.

Plate No. 90 Thin The enamel on this plate is badly burned out in the form of copperheads or rust spots, about one-third of the surface of the iron being exposed. The enamel has burned away from the edges of the plate for distances varying from $\frac{1}{16}$ to $\frac{1}{4}$ of an inch all around.

Reheating Experiments

As the blistering, which is the source of trouble, does not appear in the ground coat until after the third or fourth burning of the succeeding coats of enamel, these trials were not considered a failure at this time because they did not show a tendency to blister, but were given a "blistering fire" to develop this defect. It has been observed that enamels prone to blister, will readily do so if fired for one minute at 1600°F, or brought to a dull red. This heating of the plates to a dull red, more or less simulates what occurs in the actual firing of white and colored enamels on the sheet. The well-known practice of having finish enamels softer than the ground coat, brings about a similar condition, the metal itself probably never reaching more than a dull red in the burning of the third and fourth coats of enamel. The exact cause of this blistering is not known, but is probably due to the release of a gas from the iron or from a gas formed by a reaction between the enamel and the iron, the enamel not being brought to a sufficiently fluid state to release the gas, causing the formation of blisters.

After the "blistering fire" the appearance of the plates was as follows:

No. I Enamel

Plate No. 10 Heavy Blisters over almost the entire surface, are more pronounced where the surface of the iron is slightly rough.

Plate No. 40 Medium The size and quantity of blisters on this trial are less than on the preceding trial.

Plate No. 70 Thin The size and quantity of blisters on this trial are less than on No. 40 trial.

No. II Enamel

Plate No. 20 Heavy Blister over the entire surface. Blisters are small and do not follow any definite design.

Plate No. 50 Medium Does not show any blisters.

Plate No. 80 Thin Does not show any blisters.

No. III Enamel

Plate No. 30 Heavy Blisters slightly where enamel is very heavy, but does not blister where the enamel is of uniform thickness.

Plate No. 60 Medium Does not blister.

Plate No. 90 Thin Does not blister.

Blistering The results obtained from this investigation clearly show that there are definite limits to the boric oxide and soda oxide contents, which can be used in this type of ground coat in order to avoid blisters or rust spots. Boric oxide produces an enamel prone to blister, and soda oxide aggravates the copperheading or rust spotting tendency, so that it becomes necessary to effect a compromise in the use of these two materials.

Fishscaling The fishscaling tendency of the No. I enamel is attributed to its low coefficient of expansion. This conforms to the findings of Danielson and Souder.[1]

Cause of Blistering

The true cause of the blistering was not determined, but is probably due to a gas formed by a reaction between the enamel and the iron. The latter theory is advanced, because the physical appearance of the enamels indicates that a more complete reaction has taken place with the No. III enamel than was the case with the No. I enamel. That there actually is a reaction, is partially borne out by the work of R. D. Cooke[2], who showed that it was essential to supply free oxygen to the ware when it was fired.

It would seem from a study of the above data, that the blistering of the No. I enamel, which is high in boric oxide content, is in some measure due to the reaction between enamel and steel failing to reach a state of equilibrium under normal firing treatment. If this assumption is correct, subsequent firings would result in further combination of enamel and iron with consequent evolution of gas, which being trapped in the enamel in the viscous fluid state, which exists when the trials are heated to a dull red, results in the blistered appearance found on the No. I trials.

The extreme boric and soda oxide contents were used to give a positive indication of the effect which variations of these materials would have on an enamel of this type, and were not used for the purpose of obtaining a practical type of enamel. That the results obtained are of practical value, has been proven by the use of the information obtained in the compounding of enamels for factory use.

Due credit is accorded B. T. Sweely for his valuable assistance in preparing this paper.

Baltimore Enamel and Novelty Company
Baltimore, Md.

[1] Danielson and Souder, *Jour. Amer. Ceram. Soc.*, **4**, 620 (1921).

[2] R. D. Cooke, *Jour. Amer. Ceram. Soc.*, **7** [4], 277–81 (1924); R. D. Cooke, *Bull. Amer. Ceram. Soc.*, **4** [11], 437–42 (1924).

AGREEMENT OF GROUND COAT AND ENAMEL[1]

By A. Malinovszky

ABSTRACT

Troubles in working with enamels may be caused by poor workmanship in some department or by changes in composition of the enamel due to differences in chemical composition of raw materials used. The application of Staley's refractory ratio in determining the agreement of ground coat and enamel cover coat is illustrated.

All the recorded experiences, practices, experiments, and formulas are suggestive guides and valuable suggestions as to what to avoid, but when trouble occurs it has to be solved by our own experience and according to the local conditions.

No definite rules can be given which will apply in every plant. Every plant has to devise its own rules and methods of adjusting and correcting its troubles.

Troubles Caused by Workmanship

Trouble may not necessarily be caused by the material used in the castings or the ground coat or enamel. Workmanship in either the foundry, cleaning, or enameling department may be the seat of trouble.

Most of the articles written containing formulas do not give one formula but many. It would at first appear that one good formula for enamel to be used always on the same kind of ware would be sufficient. However, when a plant is using large quantities of raw materials they cannot always be obtained from the same source of supply. This necessitates the using of different formulas for different raw materials in order to always obtain the same results.

Any change in the workmanship or changes in the process of manufacturing will, in some cases, affect the final results.

Troubles Caused by Changes in Composition

The changes in formula, slight as they may seem, are essential to successful working because few of the materials used in enameling are absolutely pure or always constant as to their composition.

When the chemical compositions of the materials used are exactly known the formula can be changed with great accuracy. The success of any large enameling establishment depends fundamentally upon accurate chemical information.

The variations in the enamels of different manufacturing plants are largely due to differences in the raw materials used and in the processes by which they are prepared.

Often variations are so subtile that they can not be definitely ascertained though their effects may be very pronounced and effective. For example feldspar which is used as the largest raw constituent of the ground coat or enamel batch can cause a great amount of trouble.

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (Enamel Division.) Received January 14, 1927.

This is both because of the large percentage used and also because it is liable to fluctuate more decidedly than any other of the materials. Fluorspar and cryolite come next in importance as trouble makers. This is especially true of fluorspar since it differs according to its source.

Regardless of what has been published up to the present, many of the most important technical points relating to ground coat and enamels have not been mentioned.

Staley's Refractory Ratio

Staley was the first to publish an interesting and most valuable method for calculating the refractory value of the ground coat. This has given the modern ceramist his strongest weapon in controlling his ground coat and enamel.

As a matter of fact all the calculations can be made by very simple and accurate methods in an amazingly small amount of time. Short cuts in calculations may be made by the use of Staley's factors in conjunction with the tables published by A. Malinovszky.

A clear conception as to the nature of the relationship between the ground coat and enamel is shown by the following series of calculations.

Take for illustration Staley's No. 5 ground coat and his No. 5 enamel.[1] No. 5 ground coat contains the following oxides:

SiO_2	67.82	67.82	SiO_2
Al_2O_3	3.80	3.80	Al_2O_3
K_2O	1.77	.14	MnO_2
Na_2O	6.66	.18	CoO
B_2O_3	12.13		
PbO	7.50	71.94	Refractory part of the ground coat
MnO_2	.14	100.00	
CoO	.18	71.94	
		28.06	Fluxing part of the ground coat

$$\frac{71.94}{28.06} = 2.56$$ Refractory ratio of the ground coat

Enamel No. 5 contains the following oxides:

SiO_2	24.58	24.58	SiO_2
Al_2O_3	7.00	7.00	Al_2O_3
K_2O	6.42	8.50	SnO_2
Na_2O	6.53		
B_2O_3	6.04	40.08	Refractory part of the enamel
BaO	5.83	100.00	
ZnO	6.00	40.08	
PbO	17.10		
CaF_2	12.00	59.92	Fluxing part of the enamel
SnO_2	8.50		

$$\frac{59.92}{40.08} = 1.49$$ Fluxing ratio of the enamel

[1] Bur. Stand., *Bulletin*, No. 142.

Dividing the refractory ratio of the ground coat by the fluxing ratio of the enamel will give the resistance of the ground coat to the fluxing action of the enamel: $\frac{2.56}{1.49}=1.72$.

If the ground coat and this enamel had given good results, the 1.72 must be maintained, whatever changes are to be made in the ground coat or enamel or in both.

In my experience I have found that variations from 1.30 to 1.66 have given good results.

Calculations of the most successful enamels used today will come to 1.33 and 1.66. I have found that with a result of 1.20 the ground coat was too soft and was dissolved by the enamel and caused lifts, chips, and black specks in the enamel. With 1.80 the ground coat was too hard (refractory); it also was dissolved by the enamel, causing chipping, lifting, and black specks.

These differences can be also found with the enamels, so that if the enamel is too soft or too hard for the ground coat, it will cause lifting or chipping.

CERAMIC CHEMIST
WASHINGTON IRON WORKS
LOS ANGELES, CALIF.

THE ECONOMIC LIFE OF MOLDS[1]

By W. L. Sample

ABSTRACT

The economy of long service from solid cast molds is gradually offset by the loss due to excess thickness of the cast piece. An example of this is discussed, substantiated with figures.

The mold shop and casting department of a certain sanitary pottery were figuratively patting themselves on the back. All the old tank molds had been replaced by new ones, the old molds having been in service for a period of over eleven months.

Eleven months is no record for long usage for this type of mold, but it was felt, and rightly so, that this was a pretty good life for these molds, considering the severe conditions under which they had been used. This comparatively long life, coupled with the negligible replacements necessary during this time, bore mute testimony to the care with which the molds had been made, and to the care with which they had been handled in the casting shop. Hence the feeling of gratification on the part of the two departments, a feeling which was in no way concealed. Translated into dollars and cents, this long life of the molds meant lower costs, which, in turn, could be translated into higher wages.

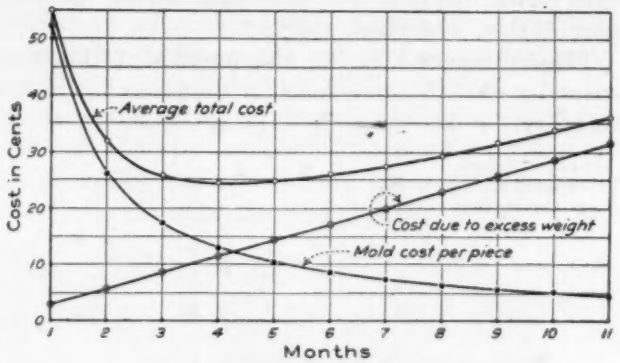

FIG. 1.

Presently there came sounds of approbation from the shipping department. The installation of the new molds was gratifying to them, too. Their viewpoint, however, was different. To them it meant a tank much lighter in weight, for the old molds were considerably worn, and, being of the solid cast type, produced a thicker piece of ware. The lighter weight meant more ease in handling, not to mention the lower freight costs for the manufacturer or customer, depending on who pays the freight.

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (White Wares Division.)

It was therefore concluded that the longer molds are used, the lower the mold cost per piece of ware, but, on the other hand, the heavier the piece of ware, or the more costly. In other words, there are two economic factors working against each other. This raised the question—would the one offset the other, and when? An investigation was made of the difference in weight of tanks cast in new and old molds, the price per pound of body material, and the cost of a tank mold.

A tank cast in an old mold in the fired state was found to weigh fifty-two pounds; a tank cast in a new mold was found to weight forty-three pounds, a difference of nine pounds. No wonder the shipping department noticed the difference, and was pleased.

An inquiry to the accounting department elicited the fact that a new tank mold cost $12.50, and that the body material cost 3.5 cents per pound. Nine pounds extra weight at 3½ cents per pound totals 31½ cents, representing the extra charge on each tank. This figure rather strengthened the suspicion that it might be false economy to use this type of mold so long, no matter how good the cast piece might be.

Dividing the cost of a new mold by the number of times used in the eleven months period gave the average mold charge per piece, which was 4.7 cents. This meant that 31.5 cents was being spent in waste to economize on a low mold charge. That settled the question about whether the economy were false or not: there remained but the question, as to when should the molds be discarded?

To decide this question it became necessary to plot the mold charge per piece against the cost of the excess body material, in terms of length of service. The mold charge curve was easy, but there were no figures to show the line of progressive excess weight. All that was known was that the piece gained nine pounds in eleven months. For want of anything more definite, the line was drawn straight, it being arbitrarily assumed that the gain in weight would be proportionate to the length of service. Though inaccurate, it was felt that the line would approximate the actual figures closely enough to give some idea of the relationship of the one line to the other.

Figure 1 shows the mold cost per piece in cents, by months. This is shown by the curved unbroken line. The straight line represents the excess weight per piece in terms of cents. The curved dotted line represents the true cost of the piece obtained by adding the mold cost and the excess weight cost, the average being cumulative. This dotted line shows that the lowest cost per piece is obtained by using a mold four months, the per piece charge being 24½ cents. Using a mold eleven months raises the cost to 36 cents, a difference of 11½ cents, and it must be remembered that this extra cost is an average

figure, and must be charged over the full eleven months. Calculating the extra charge incurred by using molds eleven months, on a basis of one hundred tanks a day, the result shows a loss of over three thousand dollars.

Data on excess weight is being carefully compiled. It will be several months before sufficient data is available for any definitely accurate conclusions to be drawn. The few figures now on hand would indicate that the excess weight line will not be so far from the straight line of Fig 1.

Research Department
Cambridge Sanitary Manufacturing Company
Cambridge, Ohio

STANDARDIZATION AND PLANT CONTROL AS APPLIED TO BODY MAKING[1]

By Frank H. Riddle and Robert Twells

ABSTRACT

The variable nature of the raw materials and the intricate methods involved in manufacture make it difficult to secure uniformity in ceramic ware. The elimination of variable factors is helped by adherence to the following rules: (1) Careful analysis of each operation. (2) Development of written standards for each operation, describing the methods and conditions found best. (3) Enforcement of the standards by careful inspection, using accurate tests after each operation to measure the results just obtained. (4) Division of the body as it is made, into homogeneous units or batches, which remain separate through the rest of the production operations. (5) Complete records readily available covering each step through which a batch passes in production. (6) Strict adherence to standard procedure even though tempted by expediency to somewhat let down the bars. The application of the above principles to body-making at the Champion Porcelain Company is described.

Introduction

There is an ever-present demand for better and more uniform ware. Better quality comes largely through research; uniformity comes through standardization and plant control. A finished product to be uniform must be produced uniformly at each stage.

Processes in which control depends upon some laborer's judgment are bound to be variable. Such steps in plant operation require careful analysis, standardization, and control by means of routine tests. In ceramic plants this is especially true in the preparation of the body since it is the foundation on which all subsequent work is built.

The need for uniformity in the body has been emphasized by the introduction of the tunnel kiln. One great advantage of the tunnel kiln is its better control of firing conditions. Variations in the composition of the body are more noticeable and are more readily traced back instead of being blamed indiscriminately on firing conditions.

The production of a body free from changes in composition is very difficult. The raw materials from which it is made are usually variable, both chemically and physically; each operation of manufacture is naturally governed by chance, expediency, and opinion rather than by exact control. These variable factors are not easy to eliminate. Thorough study of the conditions is necessary before the best method can be developed and standardized. The standard methods must also

[1]A contribution from the Research Laboratories of the Champion Porcelain Company and the Jeffery-Dewitt Insulator Company. Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (White Wares Division.) Received Jan. 4, 1927.

be enforced by means of inspections and control tests, which tend to eliminate guess work regarding the quality of the work done at each stage.

At the Champion Porcelain Company's plant much attention has been given to standardization and plant control. The methods used are by no means new or original, but the coördination of laboratory tests with production operations is unusually complete. The application of these control methods to body making will no doubt be of interest to others working on similar problems.

Raw Materials

When raw materials are purchased, their production is beyond the control of the plant; consequently they are purchased with consideration not only of their quality, but also uniformity. When a car arrives at the plant, the bin or pile into which it is to be unloaded must be inspected by the Engineering Division and released for use in writing. The material in the car must also be similarly inspected before the car can be unloaded. At the time of the inspection, samples are taken for routine tests on the material in the car. Portions of these samples are stored in bottles for future reference. Before the car can be used in production it must pass routine laboratory tests, and in addition it is tested by being made into regular body, which is processed through the Engineering Division, and actually made into fired ware. This ware must pass the same standard tests as the regular production ware before the car is released.

In most cases it is desirable to put more than one car of material in a bin.[1] The more cars of a material that can be thoroughly mixed in one bin, the better the chances for uniformity, and the longer the bin will last before a change has to be made.

The method of mixing the cars in a bin is important. The first car placed in a bin must be leveled before a second car is put in; the second car in turn is leveled before a third car is put in. This method insures a uniform mixture of the material in withdrawing it from the bin since equal parts are taken from all three cars. Another rule is that a bin must be emptied of its previous stock before being refilled with even the same material. This method eliminates questions regarding small lots left in the bin from previous shipments.

Storing and Grinding Lump Andalusite and Dumortierite

In case of shipments of lump andalusite or dumortierite from the Company's own mines, a somewhat different method of storage is followed prior to its grinding.[1] When a car is received at the plant it is inspected as already described. After the

[1] Robert Twells, "Handling and Storing Raw Materials to Produce Uniformity in a Body," *Jour. Amer. Ceram. Soc.*, 7, 82–85 (1924).

storage space has been passed on as suitable, the car of ore is dumped from a trestle into a long and narrow pile. This pile is then trued up until it is perfectly even on all sides. Subsequent cars are piled in narrow layers parallel to the first car, the slope of the pile being always kept at the same angle. This method is followed until there are usually some forty-five cars in the pile, making a total of about two thousand tons.

In withdrawing from the pile, narrow layers are taken from a side at right angles to the direction in which the cars were stored in the pile. This means that instead of using each car separately, a uniform mixture is obtained of about forty-five cars. This, of course, greatly decreases the probability of variations in the ore.

The layers taken from the pile are of a thickness of about one foot. These are carefully raked down from the full width of the pile and shoveled into dump trucks to be hauled to the Hardinge Mill. Great care is taken to maintain a uniform slope in withdrawing from the pile and to keep the layers taken of an equal thickness.

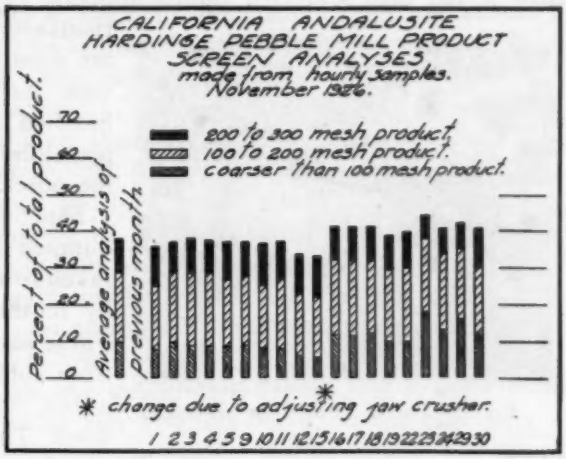

FIG. 1.—This chart was picked to show how changes in the operating conditions are followed quickly by changes in the size of the pebble mill product. Notice that most of the variation is in the percentage of material coarser than 100-mesh.

When the grinding of a completed pile is first started, a portion is drawn off the face to be sure that any uneveness such as might occur at the end of the pile has been removed; then what is termed as an average sample is taken as described and ground in advance of the time that the pile is actually needed for production. A chemical analysis is made on this average sample to determine how it compares in composition with previous piles. A batch of regular body is also made from this average sample of ore and is processed through the Engineering Division and actually made into fired ware. Any differences which might occur from one pile to the next are thus foretold long before the new pile of ore is actually needed for production. It might be mentioned here that owing to the method of selecting the ore at the

mines, and the method of storing the ore prior to grinding, the variations from one pile to the next, and within the piles themselves are practically negligible.

When a pile is to be ground for production, it is withdrawn as described and dumped near the jaw crusher of the Hardinge Unit. It is allowed to lie here until thoroughly dry. Hourly samples are taken of the products of the jaw crusher, the ball mill, and the pebble mill of the Hardinge Mill Unit. These respective samples are collected for a twenty-four hour period, following which they are turned over to the Engineering Division for screen analyses. (Fig. 1).

The sample taken at each place must conform to definite limits of fineness. The finished product coming from the Hardinge Pebble Mill is fed into standard dump hoppers, each holding about two thousand pounds. These hoppers are dumped into bins and from then on the ground ore is handled according to the same principles as have been described for purchased raw materials.

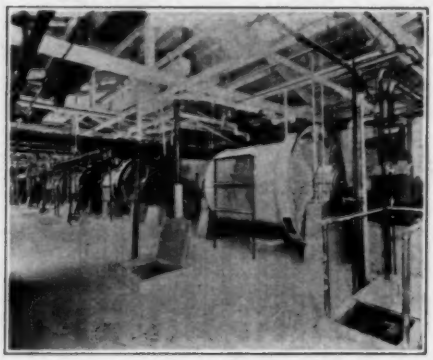

FIG. 2.—Partial view of the mill room.

Shortly before the hoppers are dumped an average sample is taken from top to bottom of each by means of a special sampler. These samples are collected, one from each hopper dumped into a bin, until the bin has been filled. The average sample of the bin is then turned over to the Engineering Division, where it is quartered and given chemical and screen analyses, which represent the final results on the bin filled with about one hundred and twenty-five tons of ground material. (Fig. 9.)

By watching the chemical analysis of each bin after it is ground from a pile, a check is obtained upon the uniformity of the method of sorting the ore at the mine, and the method of storing it in piles. The results of the chemical and screen analyses are plotted. These visual records are available at once to those interested.

Uniformity of grain size in grinding the ore in the Hardinge Mill Unit is maintained through careful control of the rate of feed to the ball mill, the size and quantity of balls and pebbles in the ball mill and pebble mill, and the minus pressure under which the whole system operates. It is also necessary to regularly adjust the jaws on the jaw crusher to compensate for wear, otherwise variation in grain size can be noted in the finished grind. (Fig. 1). The rate of feed to the Hardinge Ball Mill is controlled through a variable speed, direct current motor,

which operates a belt, drawing the jaw crusher product at a constant rate from an overhead storage bin. The size and quantity of balls and pebbles in the mills are maintained uniform by dumping and sorting them after grinding each bin. The drafts at various points in the Hardinge Mill system are controlled by means of indicating and recording gages conveniently located on a panel near the mills.

Preparation of the Body

The formula for a production body is supplied to the Production Division by the Engineering Division. Such a formula has previously been carefully worked out not only on a small scale in the laboratory, but actually has been processed through the Engineering Division on a production scale before it is definitely put into use. The formula is next changed to a size suitable to fit the mills, blungers, and storage tanks.

Definite allowance of course is made for the percentage of water in each of the raw materials. This percentage of water in the materials is determined several times a week, and the percentage of the various materials used in the body must then be altered to compensate for the percentage of moisture determined.

For every charge of body which is to be milled, a form called a "Weighing-Out Sheet" is delivered to the foreman of the mill room. This form contains complete information regarding the charge to be made: the mill number, body number, batch number, the source of each material and the number of pounds of each required, the length of grind, and the amount of water to be added. As a material is weighed for a certain charge, the weights are written and totaled beneath the amount required on the weighing-out sheet for that particular material.

The time of stopping and starting the mill and the quantity of water are also noted. The sheets when finished are carefully checked for errors. From them is made a weekly report to the Accounting Department of the withdrawals of materials for various purposes, and a running inventory is kept of the materials left in stock.

In making and handling the body, the Champion Porcelain Company uses what is termed the "batch system." A batch is a quantity of body sufficient to last each department in the plant approximately one day. By means of the batch system it is possible to check very closely each day's production in all departments, and to check any variations in the finished product back through the various departments to the original materials. After the materials for a given mill are weighed out, they are put into a steel hand truck. At once a tag is placed on the truck, showing the mill number for which the charge is intended, the body number, the batch number and the date.

Small but important ingredients such as fluxes are weighed out separately into sacks and placed upon the top of the truck, so that they can readily be checked. The complete mill charge when weighed is transferred into the mill. (Fig. 2) The batch ticket is then removed from the box to the mill and remains there as long as the charge remains in the mill. When the mill is dumped the ticket follows it to the blunger, where it again shows the body number, the batch number of the charge in the blunger, with the date at which each operation has been performed.

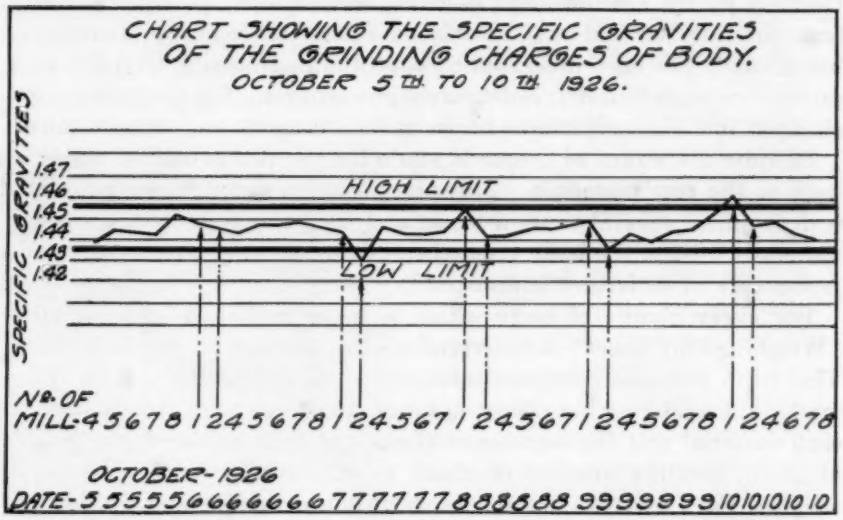
CHART SHOWING THE SPECIFIC GRAVITIES
OF THE GRINDING CHARGES OF BODY.
OCTOBER 5TH TO 10TH 1926.
SPECIFIC GRAVITIES
1.47
1.46
1.45
1.44
1.43
1.42
HIGH LIMIT
LOW LIMIT
NO. OF
MILL-4 5 6 7 8 1 2 4 5 6 7 8 1 2 4 5 6 7 1 2 4 5 6 7 1 2 4 5 6 7 8 1 2 4 6 7 8
OCTOBER-1926
DATE-5 5 5 5 5 6 6 6 6 6 6 7 7 7 7 7 8 8 8 8 8 8 9 9 9 9 9 9 9 10 10 10 10 10 10

FIG. 3—This particular chart was chosen to illustrate the uses of such curves. Notice that mill numbers 1 and 2 are not as uniform in specific gravity as the others, but that number 1 is consistently higher than number 2. As soon as such consistent trends are noted, the mills can be corrected for their individual characteristics.

With the batch system several mills are mixed together in one blunger. These must blunge together for a standard length of time to thoroughly mix them before they can be pumped out to the lawns and stock tanks.

The maintenance of uniform grinding in the mills is considered very important. It is necessary to maintain the quantity and size of the pebbles in the mills as nearly the same as possible. This is done by adding a standard quantity of pebbles with each mill charge ground. In addition the mills are dumped after every twenty-five charges and the pebbles sorted for size.

The pebbles used in the mills for grinding and the linings of the mills themselves are made from the same type of body as is being ground in the mills. This eliminates the possibility of contamination of the body from these sources.

The amount of water added to each mill charge is measured from an overhead supply tank, which has been calibrated into pounds of water per inch.

The length of time of grinding is kept constant and is checked by counters indicating the number of revolutions of the mills. After a charge has been ground for the standard length of time the mill is opened and immediately a sample of the ground materials is taken and

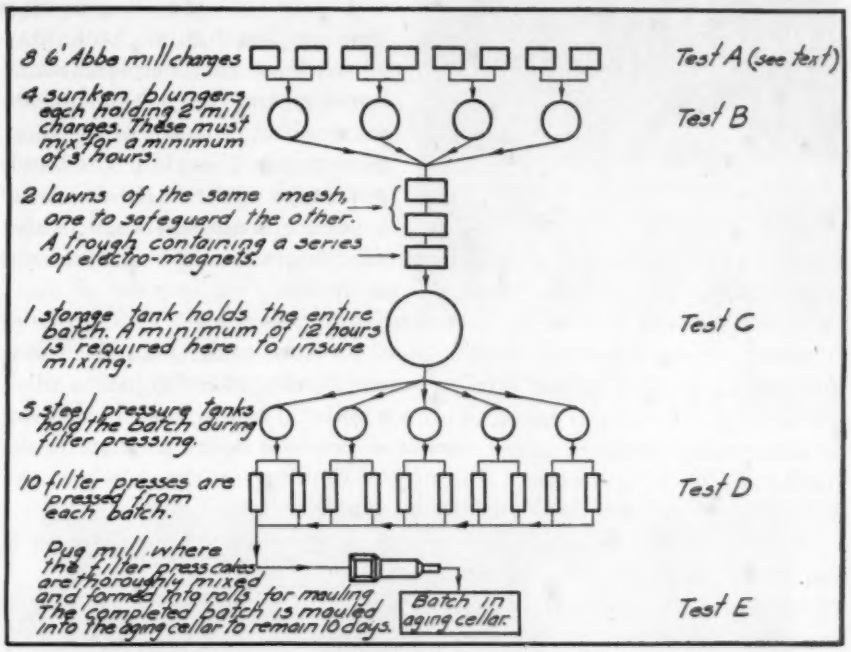
8 6' Abbe mill charges
Test A (see text)
4 sunken plungers each holding 2 mill charges. These must mix for a minimum of 3 hours.
Test B
2 lawns of the same mesh, one to safeguard the other.
A trough containing a series of electro-magnets.
1 storage tank holds the entire batch. A minimum of 12 hours is required here to insure mixing.
Test C
5 steel pressure tanks hold the batch during filter pressing.
10 filter presses are pressed from each batch.
Test D
Pug mill where the filter press cakes are thoroughly mixed and formed into rolls for mauling. The completed batch is mauled into the aging cellar to remain 10 days.
Batch in aging cellar.
Test E

FIG. 4.—Flow sheet showing the progress of a batch of body from the Abbé mills to the aging cellar.

delivered to the Engineering Division (Test A). It is tested for specific gravity, viscosity, and fineness. The results of these tests are plotted into graphs for quick reference (Fig. 3). The tests being passed successfully, the mill is dumped into a sunken blunger and mixed with other mill charges of the same body, as has been already described (Fig. 4). After the mill charges have mixed for a definite period of time, a sample is taken out of the blunger and the previous tests repeated (Test B).

The blunger charge is next run through a series of two lawns. (Fig.8.) The second lawn is similar to the first and is used as a safeguard in case of holes occurring in the first screen during lawning. From the lawn the slip flows through a magnet box and then is pumped into a storage tank large enough to hold the complete batch.

The batch tickets of course, come with the slip from the blungers and are hung on the side of the storage tank, where they give information regarding the various mills now being mixed in the tank.

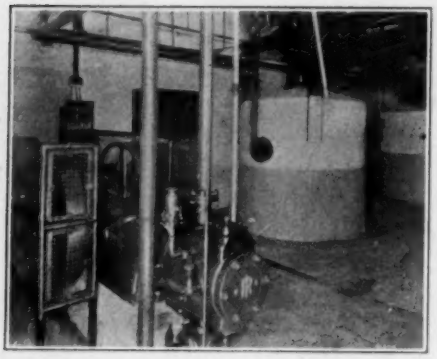

FIG. 5.—View of the air compressor and pressure tanks used in filter pressing.

A third sample is now taken and sent to the Engineering Division so that a check may be made on the completeness of lawning and upon the specific gravity and viscosity of the complete batch (Test C). The batch now stays in the storage tank for a period of not less than twelve hours. This insures that the various mill charges are thoroughly mixed and that the batch is one homogeneous unit.

Filter pressing is done by means of compressed air. The slip from a storage tank is pumped into a steel pressure tank (Fig. 5). Compressed air is then forced into the tank, forcing the slip into a filter press (Fig. 6). Care is taken to obtain uniform conditions. Indicating and recording pressure gages show the pressure in the pressure tanks as the slip is being pressed. The rate of building up the cake and the total time of pressing are carefully watched.

As soon as the press is filled, the body is weighed and a square is cut from a certain part of one of the leaves as a sample. This sample is delivered to the Engineering Division for a series of tests (Test D). One portion of the filter press sample is dried and fired through the kiln to determine any advance information possible on the batch. The filter press sample is carefully examined to determine whether or not any segregation had occurred during the filter pressing.

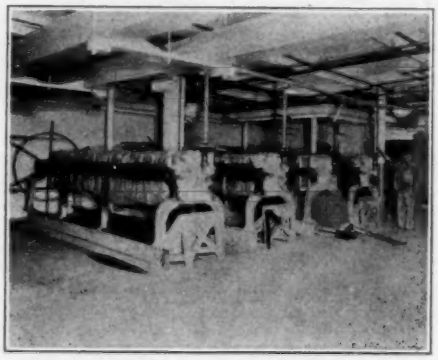

FIG. 6.—View of part of the filter presses.

The various presses in a batch are stored separately for twenty-four hours and can be separated out if necessary.

The filter press cakes are next passed through a horizontal pug and thoroughly mixed together into a roll. The batch is then carefully

mauled down into a compact pile in an aging cellar where it must stay for a period of at least ten days (Fig. 7).

While the batch stays in the aging cellar, a portion of the batch is being processed through the Engineering Division and being made into finished ware (Test E). This ware is given the same standard tests as the regular production ware, which gives a positive check upon the quality of the body in that particular batch.

When a batch first goes into the aging cellar, a red tag is placed on the pile by the Engineering Division. When the results of the processing on the batch are known, the red tag is taken off and replaced by a green tag, which signifies that the batch is released for production at the end of the regular aging period. Should the tests prove it to be wrongly made, the batch would not be allowed to leave the aging cellar for production ware.

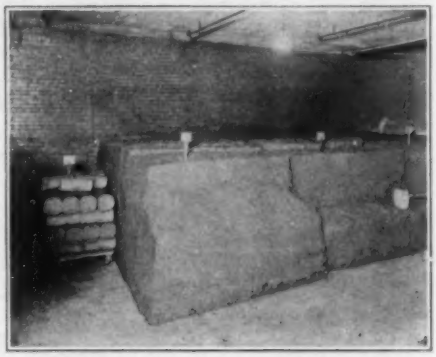

FIG. 7.—View showing the batches of body mauled in the aging cellar. Note the tickets showing the record of each batch.

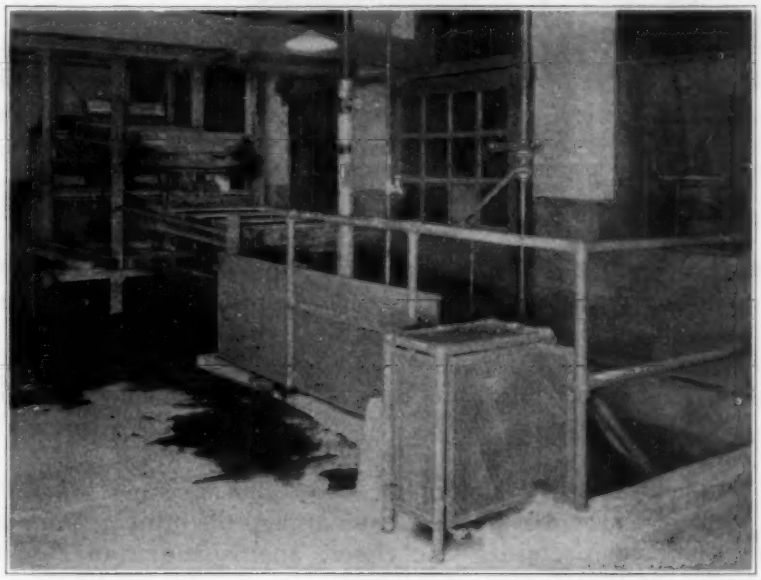

FIG. 8.—Rotex lawns in series.

After a batch of body is filter pressed, the small tickets which followed it in the slip state are collected and carefully checked. New tickets are then made out showing the various information regarding the batch, the date of milling, pressing, mauling, and total weight. These tickets follow the batch through the aging cellar to the Pugging Department, where they are fastened to the pugs while the batch is being used. They are then collected and checked. From this stage, until it finally comes from the kiln and has been tested and passed, the ware made from the batch is followed by tickets and records showing its identity.

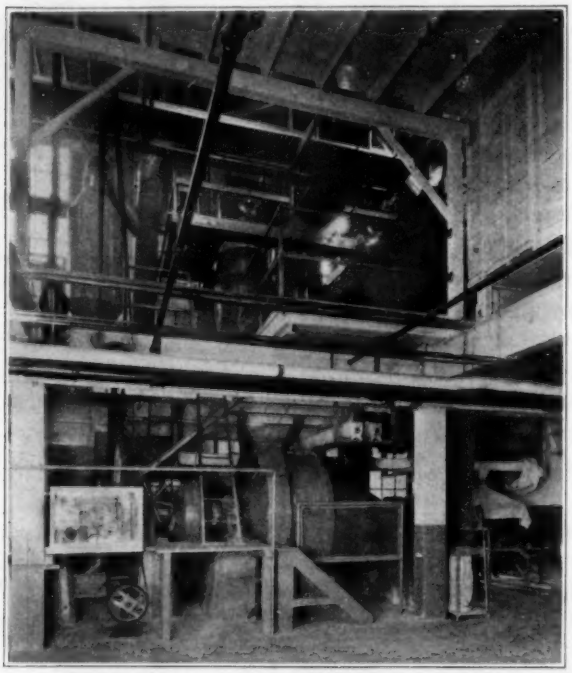

FIG. 9.—Partial view of the Hardinge Unit showing the pebble mill, the battery of dust collectors, the Hummer screen and the dump hoppers into which the ground material is fed. To the right note the sampling rod and sack holding the average sample.

A journal is kept in the Production Division showing the car numbers of materials stored in each bin or pile, the bin numbers of the materials going into each mill charge, the mill numbers of the charges going into each batch and the date of each operation in production until the batch leaves the kiln. From this data the Engineering Division plots graphs, which indicate visually the progress of any batch through the plant. A complete history of each batch is thus quickly available.

Summary and Conclusions

It is difficult to secure uniformly good quality in ceramic ware, due to the inherent nature of the raw materials and the intricate processes involved in manufacture. The closest approximation to absolute uniformity can best be secured through:

1. Careful analysis of each operation.

2. Development of written standards for each operation, describing the methods and conditions found best.

3. Enforcement of the standards by careful inspection, using accurate tests after each operation to measure the results just obtained.

4. Division of the body as it is made, into homogeneous units or batches, which remain separate through the rest of the production operations.

5. Complete records readily available covering each step through which a batch passes in production.

6. Strict adherence to standard procedure even though tempted by expediency to somewhat let down the bars.

At the Champion Porcelain Company's plant the foregoing principles have been followed for several years with gratifying success. The particular methods employed have been brought gradually into use as necessity required them. It should be remembered that this plant has had to meet the difficult conditions imposed by the use of bodies of radically different composition and behavior from those used in most plants, and the fact that the plant must produce all first quality ware. It is not to be expected that all the methods used here could be applied directly in other plants, nor are they always necessary. But other progressive companies are undoubtedly working along similar lines, using methods applicable to their problems. The goal, however, is not yet in sight. The possibilities of standardization and plant control to the ceramic industries have scarcely been touched.

CHAMPION PORCELAIN COMPANY
DETROIT, MICH.

THE EFFECT OF STEAM ON THE TRANSVERSE STRENGTH OF FIRECLAY BRICKS[1]

By C. W. Parmelee[2] and A. E. R. Westman[3]

ABSTRACT

In connection with an investigation of checker brick for carbureters of water-gas machines, it was considered desirable to find out whether or not fireclay brick suffered an appreciable decrease in transverse strength when exposed to the action of steam at a high temperature. Except for occasional references to the "destructive action" of steam, no information on this score was found in the literature. This paper describes experiments in which standard straight bricks at 1100°C were subjected to the action of steam at the same temperature and the resulting change in transverse strength measured. No significant decrease in strength due to the action of steam alone was found.

I. Introduction

(1) Object of the Experiments

In connection with an investigation of the failure of checker brick in carbureters of water-gas machines,[4] it was considered desirable to find out whether or not fireclay brick suffered a significant decrease in transverse strength when exposed to the action of steam at high temperatures. It was known that near the end of the gas-making period the concentration of steam in the carbureter was occasionally quite high (75% by volume) for short periods of time (10–30 seconds) and that consequently it should be considered as a possible cause of failure.

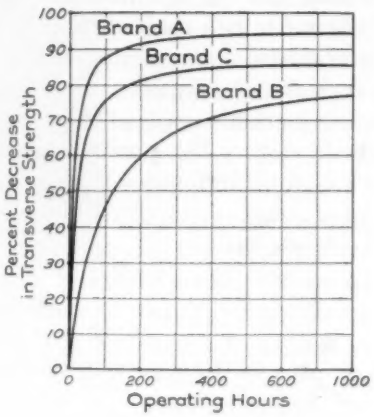

FIG. 1.

A review of the literature failed to disclose any record of experiments to determine the effect of steam on fireclay brick at high temperatures, although there were occasional references to its "strong softening action."[5] It was decided, therefore, to carry out experiments to find whether or not fireclay brick suffer an appreciable decrease in transverse strength when subjected to the action of steam at high temperatures.

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (Refractories Division.) Received December 18, 1926.

[2] Professor and Head of the Department of Ceramic Engineering, University of Illinois.

[3] Research Associate in Ceramic Engineering, Engineering Experiment Station, University of Illinois.

[4] *Jour. Amer. Ceram. Soc.*, 9 [5], 290–97 (1926).

[5] *E. g.*, Refractory Materials, Their Manufacture and Uses, A. B. Searle, p. 290.

(2) Description of Brands of Brick Used in the Experiments

Three brands of brick, which we shall call brands A, B, and C, were used in the experiments. These were chosen because their properties were fairly accurately known from previous work and their action in a carbureter had been investigated. They, also, covered a rather wide range of physical properties. A summary of their properties is given in Table I. It will be seen that they differ considerably in structure and resistance to thermal shock.

TABLE I

Brand	Manufacture	% Porosity	*Permeability cc/sec/cm pr.	§Softening point (cones)	§Firing temp. (cones)	% Strength decrease, thermal shock	§ Analyses SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO MgO Alk.
A	SMR	16.7	0.68	29–30	9–11	44.3	64.60	30.13	2.73	1.52	1.52
B	SDP	14.8	0.29	32–33	8	13.3	54.10	41.20	2.02	1.83	1.29
C	DP	23.0	2.03	30	8–10	18.1	60.48	32.68	2.12	1.32	1.23

SMR.—Stiff-mud repress; SDP.—Semidry press; DP.—Dry press.
* *Circular* No. 14, Eng. Exp. Sta., Univ. of Ill.
§ Submitted by the manufacturers.

II. Experimental Procedure

(3) Selection of Samples

Thirty-six bricks of each brand were chosen at random from large samples which had been obtained for use in service tests. The lots of thirty-six were "shuffled" repeatedly and then divided at random into three samples of twelve. In the case of each brand, one of these samples of twelve was used in determining the mean transverse strength of the new bricks, another was used in determining the mean transverse strength of steamed bricks and the third in determining the mean transverse strength of reheated bricks.

(4) Determination of Mean Transverse Strength of New Bricks

In the case of each brand, the transverse strengths of the twelve bricks of one of the samples were determined by the American Society for Testing Materials method for building brick (C21-20), the bricks being broken on edge, however, instead of flat, as this had been the method adopted in evaluating the service tests. The arithmetical mean of these measurements was calculated. Chauvenet's Criterion was used in throwing out discordant measurements. As its validity with such small samples is open to serious question, values of the mean obtained both with and without the use of the criterion are reported in Tables II and III under the caption "Mean Strength, New."

(5) Determination of the Mean Transverse Strengths of the Steamed Bricks

The second samples of twelve bricks of each of the three brands were subjected to the action of steam at 1100°C and their mean transverse strengths then determined

by the same method used in determining the mean transverse strengths of the untreated bricks.

A gas-fired, updraft kiln was used in steaming the bricks. It was 6 feet high, 40 inches wide and 30 inches deep (outside dimensions) and had nine-inch firebrick walls. Burner ports were situated at both sides at the top and bottom of the kiln. The bottom of the kiln chamber was arranged so that the hot gases from the burners at either side traveled along separate firebrick channels and then mixed and traveled through a firebrick checker work before reaching the bricks under test, which were piled, three on three, in two bungs, six bricks high, in the upper part of the kiln chamber. The burner ports at the top led directly into the kiln chamber. Thermocouples were installed at the lower and upper courses of the piles of test bricks.

The temperature of the test bricks was raised from room temperature to 1100°C in 16 hours and maintained at 1100°C for three hours. Steam was then introduced in the lower burner ports for ten hours, the temperature being maintained at 1100°C. The steam was then shut off and the kiln allowed to cool slowly to room temperature.

The steam was obtained from a high pressure steam line and was passed through a superheater, consisting of a coil of ½-inch iron pipe embedded in crushed fire brick heated by a gas burner, before being

TABLE II

COMPARISON OF THE NEW AND THE STEAMED BRICKS

	Mean strength (new) lbs./sq. in.	Mean strength (steamed) lbs./sq. in.	Difference lbs./sq. in.	Per cent difference		P	Per cent volume change	
Brand A	1152.6	1109.4	43.2	3.7	decrease	0.77	0.1	expansion
Brand B	649.2	662.5	13.3	2.0	increase	0.79	1.8	contraction
Brand B (without criterion)		687.7	38.5	5.9	increase	0.47		
Brand C	340.0	380.2	40.2	11.8	increase	0.17	0.2	expansion
Brand C (without criterion)		403.2	63.2	18.6	increase	0.09		

admitted to the kiln. The superheater raised the temperature of the steam to about 200°C. The rate of flow of the steam was regulated by means of a main valve, an auxiliary valve, and a pressure gage. The auxiliary valve and the pressure gage were connected on the line side of the main valve which was connected on the line side of the superheater. The auxiliary valve led directly to the atmosphere and drained away most of the water formed in the line. In operation, the main valve was opened half a turn and then the pressure, as indicated by the pressure gage, maintained at 20 lbs. per square inch by letting more or less steam escape through the auxiliary valve. Preliminary trials had shown that this provided a jet of steam about two feet long at the end of the half-inch pipes leading into the burner ports, or sufficient to fill the kiln chamber in about fifteen seconds. It was also found that by introducing

the steam in this way no appreciable temperature change took place in the upper kiln chamber, so that the introduction of steam did not subject the test bricks to an appreciable thermal shock.

The mean transverse strengths of the bricks so treated are given in Tables II and IV under the caption "Mean Strength, Steamed." As before, the values obtained with and without the use of the criterion of rejection are given.

(6) Determination of the Mean Transverse Strengths of the Reheated Bricks

The third samples of twelve of each of the three brands were placed in the kiln according to the same plan used in the steaming test and were heated from room temperature to 1100°C in 16 hours, heated at 1100°C for 13 hours and then allowed to cool slowly. In other words, they were subjected to exactly the same treatment as the steamed bricks, except that no steam was introduced into the kiln.

Their mean transverse strengths after reheating were determined using methods similar to those used with the new and the steamed bricks. The values obtained are reported in Tables III and IV under the caption "Mean Strength, Reheated." As before, the values obtained both with and without using Chauvenet's Criterion are given.

(7) Determination of Change in Volume

The volume of three bricks of each brand was measured before and after the steaming and reheating tests by means of a mercury balance[1] and the mean percentage volume contraction or expansion calculated for each brand. The values obtained are given in Tables II and III.

III. Interpretation of Data

(8) Significance of Differences

Tables II, III, and IV afford a comparison of the new and the steamed bricks, the new and the reheated bricks, and the reheated and the steamed bricks, respectively. In each table, the mean transverse strengths are given in the first two columns; their differences in the third columns; their differences calculated as a percentage of the mean values in the first column, are given in the fourth column; and, in the fifth columns, the "significance"of the difference is given in terms of P, the probability that they would arise from random sampling, based on "Students'"[2] Small Sample Theory, the plan of Fisher[3] being followed in the calculations. The sixth columns in Tables II and III give the percentage volume change in steaming and reheating, respectively. In Table IV

[1] *Jour. Amer. Ceram. Soc.*, 9 [5], 311-18 (1926).

[2] Biometrika XI, 414-17 (1917).

[3] Statistical Methods for Research Workers by R. A. Fisher, Oliver, and Boyd, London (1925). (Biological Monographs and Manuals V.)

TABLE III

COMPARISON OF THE NEW AND THE REHEATED BRICKS

	Mean strength (new) lbs./sq. in.	Mean strength (reheated) lbs./sq. in.	Difference lbs./sq. in.	Per cent difference		P	Per cent volume change	
Brand A	1152.6	1032.8	119.8	10.4	decrease	0.34	0.5	expansion
Brand B	649.2	680.8	31.6	4.9	increase	0.59	2.0	contraction
Brand B (without criterion)		716.2	67.0	10.3	increase	0.32		
Brand C	340.0	375.6	35.6	10.5	increase	0.19	0.2	expansion
Brand C (without criterion)		410.2	70.2	20.6	increase	0.12		

the differences are labeled "decreases" and "increases" to afford easier comparison with the difference in Tables II and III, although they are not decreases or increases in the usual sense of the term.

The value of P is based on the assumption that our samples were true random samples and that they were drawn from a normal or approximately normal population. Although these assumptions are probably quite justifiable yet it would be unwise to try to interpret the values of P too closely. High values of P, however, indicate that the difference has practically no significance, and low values that it has some significance. Our method of sampling probably gives somewhat higher values of P than a true random method.

An examination of Table II shows that, in the steaming tests, brand A has a calculated decrease in strength of practically no significance; brand B shows an increase, calculated with the criterion, of practically no significance, and an increase calculated without the criterion, of possibly very slight significance; brand C shows an increase, calculated with the criterion of possible significance, and an increase calculated without the criterion, which has some significance. Brands A and C show a slight expansion whereas brand B shows a definite contraction.

An examination of Table III shows that, in the reheating tests, brand A has a calculated decrease in strength which is of doubtful significance; brand B has a calculated increase of probably no significance when calculated using the criterion and an increase of doubtful significance when calculated without using the criterion; brand C has an increase of some significance calculated by either method. Brands A and C have a small expansion, brand C a definite contraction.

A comparison of Tables II and III shows that in both the steaming and reheating tests the data for the three brands indicate increases or decreases in strength of about the same order of magnitude and of approximately the same significance. The volume changes are also of approximately the same magnitude and direction. There is, therefore no reason for believing that the steam, of itself, had any appreciable effect on the bricks.

This is shown clearly in Table IV, where the strengths of the reheated and the steamed bricks are compared directly. The differences

are very small, vary in direction, and have no significance, as shown by the values of P.

TABLE IV

COMPARISON OF THE REHEATED AND THE STEAMED BRICKS

	Mean strength (reheated) lbs./sq. in.	Mean strength (steamed) lbs./sq. in.	Difference lbs./sq. in.	Per cent difference	P
Brand A	1032.8	1109.4	76.6	7.4	increase 0.62
Brand B	680.8	662.5	18.3	2.7	decrease 0.68
Brand B (without criterion)	716.2	687.7	28.5	4.0	decrease 0.63
Brand C	375.6	380.2	4.6	1.2	increase 0.88
Brand C (without criterion)	410.2	403.2	7.0	1.7	decrease 0.89

We can, therefore, conclude that the hypothesis that steam has no effect on the strength of fire brick at 1100°C is not contradicted by the results of our experiments.

(9) Possible Explanation The small changes which are indicated by the data in Tables II and III, taken separately, can be explained on the basis of the physical and chemical properties of the bricks, as shown in Table I. The possibly significant decrease in strength of brand A might be attributed to its low resistance to thermal shock and its relatively high firing temperature. The increases in strength of brands B and C might be attributed to their lower firing temperature and greater ability to resist thermal shock. The volume changes might be explained on the basis of composition, the bricks higher in silica expanding, the bricks higher in alumina contracting.

(10) Comparison with Service Tests Under actual operating conditions, high concentrations of steam occur usually just at the end of the gas-making period, or for about 10 to 30 seconds of a 4-minute cycle, *i. e.*, approximately 10% of the operating time. Figure 1 shows the per cent decrease in transverse strength which was found for brands A, B, and C in service tests in actual carbureters in terms of the operating hours. If the action of steam were the major cause of failure, we would expect that 10 hours continuous steaming, which would be approximately equivalent to 100 operating hours, would cause decreases in strength of about 87% for brand A, 45% for brand B, and 75% for brand C. A comparison of these values with those given in Table IV shows that this expectation is not realized and that therefore the effect of steam is not an important factor in the failure of these brands when used in a carbureter.

(11) Significance in Regard to Fire Brick in General It must be pointed out that in the above experiments we have used only three brands of fireclay brick out of some 350 or more brands which are manufactured in the United States at the present time. If we consider these brands as a sample of three from a

large number of brands, the average percentage difference between the reheated and the steamed brick, which is about 2% in favor of steamed brick has a value of P of nearly 0.9, or has no significance. Any application of the conclusions based on these three brands to fire brick in general must be based on our judgement of how representative they are of the large number of brands manufactured.

IV. Summary

(12) Experiments A description has been given of experiments in which the mean transverse strength of samples of twelve of each of three brands of fireclay brick have been determined (*a*) on new brick, (*b*) on brick which have been subjected to the action of steam at 1100°C for 10 hours, and (*c*) on brick which have been reheated so as to act as "controls" for the steamed brick.

(13) Conclusions An analysis of the data obtained has led to the conclusions that (*a*) the hypothesis that steam at high temperatures has no effect on the strength of fireclay brick is not contradicted by the data, (*b*) the effect of steam is not a major factor in the failure of fireclay brick when used as checker brick in carbureters.

(14) Recommendations It would seem worth while to carry out more experiments, similar to those reported in this paper, but with (*a*) larger samples, (*b*) more brands of brick, (*c*) longer steaming periods and means for determining the percentage of steam present in the test kiln during these periods. The data secured from such tests would be more applicable to fire brick in general and would probably enable us to eliminate any necessity for considering the possible effect of steam on our refractories, thus resulting in simplification of our problems. In the meantime, references to the "destructive action of steam" are hardly justified.

V. Appendix

Color of Treated Bricks It may be of interest to report that the colors of both the reheated and steamed bricks were much darker than the new bricks, the small iron spots showing up very plainly. This effect was much more pronounced in the case of the steamed bricks, which also showed a tendency toward reddish shades.

ACKNOWLEDGMENT: The funds for this investigation were provided by the Utilities Research Committee which is composed of representatives of the following companies: Commonwealth Edison Company, Peoples Gas Light and Coke Company, Public Service Company of Northern Illinois, Middle West Utilities Company, Chicago Rapid Transit Company, and Chicago North Shore and Milwaukee R.R. Company.

THE USE OF SUPER-REFRACTORIES AS CHECKER BRICK IN GAS MANUFACTURE[1]

By H. J. Knollman[2]

ABSTRACT

During the past year, Carbofrax and Diamel brick, each having distinctly different but superior, heat-transfer properties as compared with fire brick, were tried out as part of the regular checker brick in a full-sized standard single-shell oil-gas generator, which was operated under normal conditions. It was hoped that increased gas-generating capacity would be obtained by their use, but such was not the case, chiefly because of the influence of other factors having as much bearing on generator capacity as the checker brick.

The chief limiting factors were (1) the remoteness of a large portion of the checker brick from the combustion chamber and therefore from the source of heat supply; (2) uneven heat distribution in the generator; and (3) the formation of heavy cokelike carbon deposits on a portion of the checker brick. With the development of improvements in the generators and the correction of some of these difficulties, there appear to be excellent possibilities in the use of brick of superior heat-transfer properties in promoting operating efficiencies and in increasing gas production.

I. Introduction

The refractories requirements for oil-gas generators and for the actual manufacture of oil gas were given in a paper presented at last year's symposium on gas-works refractories held by the Refractories Division of this Society.[3] In addition to the properties required and the common causes of failure of the refractories, the heat-transfer and heat-absorption properties of various types of refractories were discussed. A study of the various types of refractories having superior heat-transfer properties led to the conclusion that they possess characteristics that should prove to be advantageous in enabling them to make an increased amount of gas in a unit of time, and to thus materially increase generator capacity when used as checker brick in the generator.

Selection of Refractory Types

The various refractories available for use that have one or more heat-transfer properties superior to fire brick are silica, magnesite, fused magnesia, Carborundum, Diamel, Alundum, and chrome brick. Specimens of each of these refractories were placed in a generator in regular operation so as to determine in a preliminary way which would be likely to withstand service conditions. The magnesite type of refractories was eliminated from further consideration, since it cracked or disinte-

[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (Refractories Division.) Received January 1, 1927.

[2] Ceramic Engineer, Los Angeles Gas & Electric Corporation, Los Angeles, Calif.

[3] H. J. Knollman, "Refractories for Oil-Gas Manufacture", *Jour. Amer. Ceram. Soc.*, 9 [12], 860–87 (1927).

grated. Although silica brick withstood the preliminary conditions without spalling and cracking, they were discarded because of the extra precautions necessary to make their use practical, together with the fact that their heat capacity is slightly lower than fire brick, while their conductivity and time required for heat saturation are only moderately greater than for fire brick. Chrome brick have a lower conductivity than fire brick so that they were not particularly suitable compared with others with more attractive heat-transfer properties. Carborundum were especially suitable because of their very high conductivity. Diamel and Alundum have similar properties, with the heat capacity and time required to reach heat saturation slightly in favor of the former, so that it was chosen for further investigation.

During the past year, these two super-refractories, Carborundum and Diamel (fused magnesia spinel), each having distinctly different heat-transfer properties, were used in a large way in generators operated under normal gas-making conditions, and were used as part of the checker-brick requirements of the generators in question. These trials are probably the first that have ever been made where special brick having well-defined special heat-transfer properties were used as checker brick in an industry where such properties are of importance. It is the object of this paper to present not only the general results but to point out the chief factors that have placed limitations upon the brick when used in this capacity, whereby the results expected from theoretical considerations are not always obtained.

Thermal Properties of the Refractories Investigated

In reviewing the relative thermal properties of Carborundum, Diamel, and fire brick, it is seen that, according to the best available information, the conductivity of Carborundum is from 7 to 8 times that of fire clay, while that of Diamel is a little more than double that of fire clay. The density of both super-refractories is considerably higher than that of fire brick. Silicon carbide has the lowest specific heat and Diamel the highest. The heat capacity of Carborundum is only slightly greater than that of fire brick, while Diamel has nearly $1\frac{1}{2}$ times the heat capacity of fire brick. The diffusivity of heat through Diamel is only about $1\frac{1}{2}$ times that of fire brick, while that of Carborundum is about 6 times greater than fire brick. Finally the time required to reach nearly complete (95%) heat saturation is only about $4\frac{1}{2}$ minutes for a standard 9-inch Carborundum brick, nearly 30 minutes for fire brick, and slightly over half of the latter length of time for Diamel. These values hold true if the average temperature to which the brick is exposed is 1700° F—a value close to that found in oil-gas generators. These are the chief heat-transfer properties that were considered as a basis of selection of the above

refractories, along with indicated ability to withstand service requirements.

Description of Oil-gas Generator

The trial runs were made at the plant of the Los Angeles Gas & Electric Corporation in standard generators of the type described in last year's paper.[1] The single-shell generator consists essentially of a cylindrical, vertical steel shell, lined to a greater or less degree with some form of insulation next to the steel, followed by one or two courses of fire brick, which make up the generator side walls. There are two long combustion chambers at the bottom of the generator, separated by a firebrick center wall. Overhead are the arches, which are generally made up of two or three separate rings laid directly over each other and spaced about 6 inches apart, thus allowing the hot gases to pass on up between them. They support the mass of checker brick overhead. The checker brick generally consist of standard 9-inch brick, spaced from $2\frac{1}{2}$ to $3\frac{1}{2}$ inches apart in regular checker fashion, thus leaving open spaces through which the gases travel. The roof consists of fire brick on the inside of the gas chamber, with loose insulation between the fire brick and the steel roof on the outside. On top is the stack valve, open while heating and closed while making gas.

Entering the two combustion chambers at the bottom are blast pipes admitting air for combustion and burners for conveying the oil for heating, which are located in opposite ends of the respective combustion chambers. The heating is accomplished by means of a long flame burning throughout the length of the combustion chamber. During the heating period there are, therefore, two long flames burning in the combustion chambers underneath the checker-brick section, a heating arrangement which tends to distribute the heat rather unevenly. The hot gases travel upward through the checker brick and exit through the stack on top.

Generator Operation

The generator operation is intermittent in its action. At the start of the making period of the operating cycle, finely atomized oil and steam are sprayed through injectors located above the upper course of checker brick upon the heated checker brick in the generator. The atomized oil and steam travel down through the checker brick and are converted to a gas of about 550 B.t.u. value, accompanied by the formation of considerable lampblack carbon, and small amounts of tar and naphthalene. Often heavy cokelike deposits of carbon are also formed on the upper courses of the checker brick. When the checker brick have cooled sufficiently so that gasification of the atomized oil and steam is no longer complete

[1] *Loc. cit.*

and satisfactory, the generator is purged of the remaining gas, and the heating period of the cycle is started. The checker brick are then heated up to the proper gas-making temperatures, whereupon they are again ready for gas making.

The temperatures may vary considerably in different sections of the generator, ranging from about 1300° F average in the upper courses of checker brick (just below the introduction of the oil and steam to be gasified), to around 1800 to 2100° F in the lower courses of checker brick and in the arches just above the combustion chamber. The time required for the heating and making periods of the cycle also varies considerably, according to the size and type of generator used. The usual variations are from 5 minutes heating, 5 minutes making as a minimum, to 15 minutes heating, 30 minutes making as a maximum.

The Various Checkerbrick Locations in the Generator

The smallest generators available for the experimental runs were 22 feet in diameter by 35 feet high. Each generator normally requires in the neighborhood of 35,000 standard checker brick, too large a quantity to warrant complete checkering with the above super-refractories, since their initial cost would be so excessive that, even with exceptionally good results from their use, complete checkering did not appear to be economically sound. Approximately 7,000 standard 9-inch Carborundum brick, or 20% of the whole, were finally selected for test. The same was true for the Diamel brick.

Immediately the problem of the best location for these brick presented itself. Since under normal operating conditions the top temperature average is only around 1300° F as against 1600 to 1700°F in the middle section, and 1800 to 2000° F in the lower section just above the arches and combustion zone, it appeared as though it might be difficult to furnish sufficient heat to the super-refractories if they were located in the upper portion of the checkerbrick column. Not only are the upper checker brick farthest removed from the heat source in the bottom of the generator, but these brick are also constantly cooled more readily and rapidly than the remainder because of the introduction of the oil and steam for gas manufacture through the injectors located above the top checker brick. The lower checker brick function mainly as a heat reservoir for "fixing" the gas after the oil and steam have been decomposed by the upper heated checker brick. Since the upper checkerbrick section is the active gas-making section, this was considered to be the most logical and best selection for placing the super-refractories, even though the location would be disadvantageous from a heating standpoint. If the super-refractories were to be of distinct benefit in practical gas manufacture, it could only be in the active

gas-making zone of the checkerbrick column. The upper ten courses of the checker brick were therefore composed of Carbofrax in the first test and of Diamel brick in the second test.

Manner of Conducting the Investigation

The prime object of the investigations was to determine whether increased gas-making capacity could not be obtained from the generators if brick of superior heat-transfer properties were used. The experimental runs were conducted under normal conditions in the same manner as in regular plant operation. The blasts and fuel in both combustion chambers were recorded at all times. The total blast, total fuel and make oil, and total make steam were also recorded. In addition, the generators were equipped with a number of pyrometers located in various sections of the generator so that a study of the heat distribution in the different checkerbrick sections could be made, as well as obtaining the actual temperatures of the brick under test. In order to obtain a comparison between fire brick and the super-refractories, the generators were first operated with fire brick throughout, and after sufficient data for comparison had been secured, the super-refractories were substituted, as already outlined.

II. Factors Affecting the Heat-Transfer Properties of Checker Brick

Generator Capacity Obtained

It was found that with proper control practically the same gas capacity was obtained from the ordinary fire brick as from the super-refractories, although excessive gas production for long periods of time could not be maintained. Greatly increased gas-making capacity was therefore not realized from the use of the Carbofrax or Diamel brick, due to the influence of other factors which limited their value in this connection.

Remoteness of Checker Brick from the Heat Source

One of these factors was that already mentioned—namely, the difficulty of bringing sufficient heat at a slow enough rate to the upper checker brick so as to obtain full advantage of their superior heat-transfer properties. Because of the high velocity of the hot blasts through the generator, the hot gases passed by the brick so rapidly that they could not absorb the heat as readily as the lower checker brick which were constantly saturated with a steady supply of heat during the heating period. Consequently the heat was not readily diffused through the upper checker brick. An excess of blast air is necessary, however, in oil-gas generators, not only because of the resistance offered to the passage of the gases through the checkerbrick column, but also to keep the upper checkerbrick spaces open so that the flues between the brick will not become partially or

wholly closed with cokelike deposits of carbon due to incomplete gasification of the oil introduced through the injectors at the top. Especially is a heavy blast necessary when the generator is forced, and when excessive amounts of oil and steam are introduced. Consequently neither the Carbofrax nor Diamel brick stored up any largely increased amounts of heat in the brick during the heating period as compared with fire brick. Only when the presence of glowing carbon particles on the top checker brick supplied a secondary source of heat did the Diamel brick store up greater quantities of heat, while the Carbofrax brick gave up their heat so readily in the gas-making periods that the heat capacity of the brick did not exert itself strongly.

In the case of the checker brick in the upper zone of the generator, the heating of the bricks is largely a surface phenomenon, whereby they are heated mostly on the surface and the heat is not diffused through them, regardless of their heat-transfer and heat-storage properties. Such is not the case in the lower checkerbrick sections of the generator where the bricks are in contact with a constant source of heat supply during the heating period. The heat-transfer coefficient from gas to brick strongly exerts itself in this case. The heat-transfer rate of the hot gases to the brick surface becomes very low with high gas velocities whenever the products of combustion are quickly blown out through the stack. With a low coefficient of heat transfer from gas to brick, the amount of heat absorbed by the brick diminishes. This factor had an important influence on the use of these upper brick and proved to be an important one in influencing the results obtained from the different kinds of refractories tested.

Uneven Heat Distribution

The difficulty just discussed applies to the checker brick as a whole, but it does not hold strictly true in that the heat distribution in the generators is not uniform. The uneven heat distribution is primarily due to the fact that two burners opposite each other, one in each combustion chamber, produce two long flames in the combustion chambers in an otherwise large round generator—an arrangement which is not conducive to even heat distribution. Increased gas-making loads require increased fuel at the same time in order to store up the increased amount of heat necessary to gasify the increased oil and steam to be converted into gas. Consequently the flame lengths are then increased so that the uneven heat distribution always becomes more pronounced with increased loads. The result is that there is a decided tendency to the formation of localized hot and cold sections in the generator whenever the generators are forced to increase their capacity, which heat concentration extends to a lesser degree also to the top checker brick.

Both the Carbofrax and Diamel brick greatly accelerated the formation of these localized hot and cold sections in the generator, which became especially pronounced when heavy gas-making was being done. The Carbofrax checker brick particularly promoted this action, since they absorbed the available heat in the hotter sections of the generator during the heating period much more rapidly than the others, especially more so than the fire brick. The Diamel brick did not absorb the heat as rapidly as the Carbofrax, but on account of their high heat capacity large quantities of heat were stored up during the heats so that they held it very effectively in the sections where they were exposed to excessive heat flow from the combustion chambers. Less heat was given up in these sections during the succeeding gas-making period of the cycle, so that a gradual building up of the heat in these sections took place, especially whenever the generators were forced. In a similar manner, pronounced cold sections were also built up in the generator, since it was equally natural for the brick farthest removed from the flame and source of heat supply to be inadequately supplied with sufficient heat during the heating period of the cycle to take care of the necessary amount of heat required in the succeeding gas-making period. Here again the Carbofrax brick that were most remote from the heat source lost their heat at a much faster rate than the fire brick, so that they especially became colder when increased amounts of oil and steam were introduced to be gasified. The Diamel brick did not give up their heat so rapidly, so that, although they could not store up large quantities of heat, they did not give as pronounced cold sections, but resembled more nearly the regular fire brick. The cold sections were very persistent, however, since the brick gave up their heat rapidly and not much of it was brought to them from a relatively remote source of supply during the heating periods to compensate for the heat lost when the oil and steam were gasified.

The net result was that the average temperature differences in the upper checker brick were greatest when Carbofrax brick were used, followed by Diamel, while ordinary fire brick showed the least difference in average temperature between the localized hot and cold sections in the generator. This had a considerable influence on generator operation in that the generator was most erratic in its operation with the Carbofrax brick. It was more difficult to control the quality and B.t.u. of the gas made. More frequent changes in fuel ratio were necessary to keep the generator in balance, although a small saving in total fuel was obtained. The generator was more apt to become either too hot or too cold as a whole with an adverse effect on the B.t.u. of the gas made and an increased yield of the undesirable by-products—lampblack or tar. When Diamel brick were used this tendency was not quite so rapid or noticeable, so that slightly more stable conditions were maintained.

In this particular respect, the ordinary fire brick gave the most stable operating conditions.

Effect of Heavy Carbon Deposits

A third factor that greatly influenced the results obtained in the trial runs was the formation of heavy cokelike deposits on the top checker brick. In the production of oil gas, two different kinds of carbon are formed: (1) a loose lampblack form of carbon, which is inherently a part of the gas-making reaction, and (2) a hard cokelike form of carbon generally deposited on the top checkers under the oil sprays or injectors. The former does not influence the generator operation, but the latter exerts considerable influence on the heat distribution, generator capacity, and heat-transfer properties of the checker brick affected by it. The latter deposits are formed when the checker brick are saturated with oil to such an extent that it is not completely gasified, but is partially cracked, accompanied by the formation of heavy carbon or coke residues. Expecially with heavy loads is it difficult to heat the top checker brick sufficiently and at a high enough temperature to completely gasify the oil. This naturally becomes worse with increased amount of oil and steam to be converted into gas.

Previous to their use, it was hoped that the super-refractory checker brick would be able to prevent the formation of these heavy carbon deposits, but such was not the case in so far that when the brick were saturated with excessive quantities of oil and steam they were likewise cooled to the critical temperature where they could not completely gasify the oil, the heavier oil fractions forming a cokelike residual product. The additional amount of heat that they were able to absorb, as compared with fire brick, was not sufficient to completely gasify the oil. The Carbofrax brick resisted the formation of solid carbon deposits much better than fire brick, except where the localized cold sections were present. There the brick soon became coated with the deposits. Whenever the brick had an opportunity to become heated sufficiently to ignite the carbon, the carbon would tend to burn off of the brick and incidentally to heat them to a temperature sufficient to more completely gasify the oil. As a result, the formation of large carbon deposits was much slower than for fire brick under similar conditions. The Diamel brick also were effective in reducing the rate at which the carbon deposits were built up in the generator as a whole. Under favorable conditions they were capable of storing up more heat than the fire brick, which reduced the amount and rate of the cokelike deposits in a given period of time. With very heavy loads, however, the differences between the behavior of the three refractory types became less pronounced, and the deposits built up very rapidly in those sections where the brick were excessively saturated with oil and steam. The Carbofrax brick then became chilled very rapidly and soon became

cold and black and were ineffective for further gas-making operations. A heavy deposit of carbon formed over the brick and closed up the checker spaces between them, rendering them inactive and dead, regardless of the type of checker brick being used.

Except where the coke deposits were very heavy, the presence of small quantities of glowing carbon tended to reduce the uneven heat distribution previously mentioned. The heat distribution of the upper few courses of checker brick was more uniform than in the lower courses farther down in the generator because of the scattered particles of glowing carbon fairly uniformly distributed over the top checker brick. This condition was also advantageous in that the presence of carbon particles radiating heat increases the heat transmission materially by raising the brick temperature, and thus making use of the superior heat-transfer properties of the checker brick under test. The heat-transfer coefficient from gas to brick and vice versa is raised thereby. This was advantageous, however, only when the checkerbrick spaces were kept open at all times, while the formation of the heavy carbon deposits was decidedly detrimental and very materially reduced the generator capacity, regardless of the type of checker brick used.

Causes of Heavy Carbon Deposits

The development of heavy deposits of cokelike carbon on the upper checker brick is primarily dependent upon the manner of spraying the oil and steam on the heated checker brick, and not upon the heat-transfer properties of the brick, since none are able to resist this formation when placed in the unfavorable position of being too far from the source of heat combined with constant saturation with excess quantities of oil and steam. The characteristic location of these carbon lumps is in the central portion of the generator, due to the fact that the oil injectors, although placed at frequent and regular intervals around the periphery of the generator, spray the oil and steam in comparatively long and narrow, finely atomized streams toward the center of the generator. Consequently an appreciable proportion of the oil and steam from the individual sprays meet in the center of the generator, resulting in the formation of coke in this region. Usually this coke formation occupies but a small portion of the entire cross-sectional area. The center lump continues to grow slightly with each succeeding cycle however, so that under favorable circumstances, or with overloading of the generator for long-continued periods of time, the deposits may assume such large proportions that the carbon has to be ignited and burned off through continued heating operations. The generator capacity is naturally reduced by this troublesome factor, which has been difficult to overcome, when excess capacity is required over long periods of time. With the development of injectors so located that the oil and steam to be gasified are sprayed uniformly over the entire checkerbrick area, the possibilities of success in the use of brick of superior

heat-transfer properties as compared with fire brick would be greatly enhanced. This is claiming the attention of the industry at the present time.

III. General Conclusions

Various Factors Affecting Generator Capacity

The results of some tests and experimental runs made in oil-gas generators when using Carbofrax and Diamel brick as part of the checkerbrick requirements have been given. They showed that a more even heat distribution within the generator and a more uniform distribution of the oil and steam to be gasified are absolute necessities before increased capacities and better operating results can be expected from refractories having superior heat-transfer properties. The checker brick are but one of several major factors entering into the question of generator capacity and gas production. Some of these, such as the type of injector used, generator diameter in relation to the oil sprays, tendency to unequal heating and cooling of the checkers in the generator, poor temperature distribution, distance of the majority of the checker brick from the source of heat, are factors of as great importance as the heat-transfer properties of the checker brick and have a profound influence upon the behavior of such refractories in the generator.

Future Possibilities

Nevertheless the Carbofrax and Diamel brick, because of their increased heat capacities, decreased length of time required for 95 per cent heat saturation, and greater ability to absorb or release heat, proved to be the medium whereby the need for suitable changes in some of these factors were pointed out very clearly. They strongly indicated that brick of superior heat-transfer properties present excellent possibilities of materially increasing generator capacity and efficiency of operation, when more uniform heat distribution, more uniform introduction of the oil and steam to be gasified, and better facilities for heating the upper checker brick are provided. It appears probable that if the checker brick were heated in the same direction as that of the gas manufacture, that is, if the checker brick were heated from the top instead of the bottom as at present, much better results would be secured by the active gas-making checker brick and that then the Carbofrax and Diamel brick would have shown up to much greater advantage. Likewise their use appears to present much greater possibilities in small generators where these satisfactory operating conditions can be met more readily than in the larger generators, where conditions are sufficiently unfavorable to make it difficult to realize the results otherwise to be expected from the use of brick of the types tested. As a result, the development of better operating conditions along these lines is claiming the attention of the industry at the present time.

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THE ELIMINATION OF LAMINATION IN CLAY BARS[1]

By A. F. Greaves-Walker[1]

ABSTRACT

The cause of lamination and methods of reducing or eliminating it are discussed.

Lamination in stiff-mud clay bars may be caused by either auger or die, or both, or may be due to physical properties of the clay. Each clay is an individual problem.

Trouble may be partially or wholly eliminated by varying auger distance, changing type of barrel, taper of die, length of die, changing speed of column, proper lubrication, and other means.

Introduction

In any discussion of the elimination of lamination in a stiff-mud clay bar the following points must be kept in mind:

1. Each clay presents an individual problem.
2. Lamination can be eliminated or reduced only by intelligent experimenting.
3. Once having produced the conditions which eliminate lamination or reduce it to a minimum, those conditions must be adhered to within very narrow limits.

Definition

Lamination may be defined as a series of ununited planes of separation in a clay bar caused by the slicking or smoothing action of metal surfaces or by differential flow.

Kinds Two kinds of lamination are encountered in clay bars, *viz.*, auger and die. These may occur separately or combined. The great majority of lamination problems can be traced to the die and it is this kind that is the most difficult to eliminate.

The two kinds are usually easy to identify, the separation planes in die lamination being concentric around a central core while in auger lamination the planes may run in any direction through the bar approximately parallel to the line of flow.

Causes of Lamination

Physical Factors All lamination is caused by an unbalanced system of the following factors:

1. External adhesion (clay to metal)
2. Internal friction (clay to clay)
3. Internal cohesion (clay to clay)
4. External friction (clay to metal)

The individual effect of these four factors on clays of different types will be as follows:

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[1] Presented at the Annual Meeting, American Ceramic Society, Detroit, Mich., Feb., 1927. (Heavy Clay Products Division.)

[2] North Carolina State College, Raleigh, N. Car.

	Sandy clays	Clays of good plasticity	Sticky plastic clays
External adhesion	low	medium to low	high
Internal friction	high	medium to high	low
Internal cohesion	low	" " "	high to medium
External friction	high	" " "	high

To overcome lamination these factors must be played, one against the others. It will be readily seen that an increase of internal cohesion (clay to clay) when combined with pressure would eliminate auger lamination, while an increase of internal friction, (clay to clay) and internal cohesion (clay to clay) and a reduction of external adhesion (clay to metal), and external friction (clay to metal), will eliminate die lamination. For example, if less water is added to a shale in pugging, the clay particles will not slip on each other as easily; the clay is said to be less plastic; the internal friction has been increased. If sharp grog is added to a clay internal friction is increased. The grog particles resist movement, thus preventing the clay particles from slipping and forming planes. If the speed of the bar is reduced or the lubrication is increased the external friction is reduced.

Physical Properties of Clays

The tendency of a clay to laminate will depend upon its physical composition. Clays are composed of mineral particles varying in size from relative coarse down to colloidal dimensions. Sandy clays or those containing coarse rock fragments give little or no lamination trouble while those high in particles of colloidal dimensions, the very plastic clays, are usually troublesome.

In pressing out a clay bar from the unconsolidated mixture fed into the machine hopper, there is naturally an adjustment of the clay particles. It has been definitely shown that the pressure, applied in the direction of the bar flow, squeezes out some of the colloidal portion from between the larger grains and in the direction of the pressure. These very fine grains collect in the directions perpendicular to the pressure thus providing ideal conditions for the establishment of lamination planes. Furthermore clay particles of platelike structure will orient themselves so that the largest surfaces are parallel to the lines of flow at the surface of the planes. With air and water as lubricants they thus aid materially in producing ideal conditions for differential flow.

Water Content

Water is the agent of plasticity. Surrounding the clay grains it acts as a lubricant, reducing the internal friction. Additions up to a certain point increase the internal cohesion, beyond that point water reduces cohesion. Considering only water contents within the range of workability, the higher the water content, the greater the possibilities of differential flow. On the other hand

increasing the water content will reunite the separated planes more readily after the bar passes the die mouth, but as an offset produces greater external friction in moderately plastic to plastic clays.

Some idea of the effect on the clay bar of varying the water content can be had from the fact that the pressure required to push out the column varies inversely as the plasticity.[1] In a recent test on an auger machine it was found that a reduction from 28 to 22% of water increased by 115% the power required to drive the machine.

Air Content What effect the air content of the clay bar has on lamination has not been definitely determined, but sufficient progress has been made to assume that it is an important factor. Spurrier[2] found that the layers of clay next to the die were of greater density and had a lower air content. In the outer half-inch layer of the bar he found 2.67% by volume of included air while the layer just beneath contained 11.9%. This indicates that the pressure caused by the die taper forces the air from the outside toward the center of the bar. As a film of air will act as a splendid lubricant this forcing of the trapped air to the center of the column gives additional lubrication to the clay particles in that portion where it will do the greatest harm. This points to the necessity of keeping the machine barrel full of clay at all times.

Methods of Elimination

Auger Lamination This is the easiest of the two kinds to eliminate. It is caused by the slicking or smoothing action of a smooth metal surface on clay passing over it. It is obvious that the larger the barrel and the greater the pitch of the auger the smaller will be the percentage of clay coming in contact with metal. This would seem to argue for barrels of large diameter but as the taper from barrel to die is also an important factor the size is limited. It is sufficient to say that taking all other factors into consideration, the barrel should be as large and the auger pitch as high as possible.

Single and Double Tip Augers Single augers give the greatest column speed and also give the least contact between metal and clay. They have the drawback however, of giving a differential flow from side to side which often produces serious drying troubles.

Double lip augers delivering two streams overcome this differential but displace more clay and offer a larger metal surface to the clay.

[1] G. D. Morris, "Flow of Clay through Hollow-ware Dies," *Trans. Amer. Ceram. Soc.*, **19**, 479 (1917).

[2] H. Spurrier, "Studies in Pug Mill Control," *Jour. Amer. Ceram. Soc.*, **3**, 388–403 (1920).

They also require more power. The double lip auger has the advantage of delivering two spirals which have a tendency to break each other up thus partially destroying the smoothed surfaces.

Auger Distance When the auger is close to the die and running at high speed the column acts more like a true solid and greater pressure is exerted at the center making it move faster in that area. This effect is more noticeable with a single than with a double lip auger.

In order to distribute the effect of the auger over a greater area and to break up the spirals, prevent weaving and destroy slicked surfaces, it is necessary to provide a reservoir between the auger tip and die. The greater this distance the better the chance to eliminate auger lamination and the more uniform will be the flow of clay over the whole area of the die opening. It should be remembered however, that in increasing this distance the power required to drive the machine varies as the square of the distance.

Taper of Barrel The taper in the extention of a brick machine barrel is designed to compact the clay, squeeze out the air, equalize the moisture and knit the spirals from the auger. It is worthy of note that straight barreled hollow tile machine and sewer pipe presses produce ware that meet as rigid requirements as are demanded of brick. As auger lamination would be more serious in hollow tile than in brick and as hollow tile manufacturers do not suffer from it, this brings up the question as to the superiority of the straight over the tapered extention and the straight over the tapered auger.

The relation of speed or ease of flow to the taper of the extention is also of interest. Those who have experimented with dies recognize that there is a maximum speed taper or a taper that will allow the clay to flow with maximum speed. If this is true of dies it should be no less true of barrel extentions. Nothing has been determined on this point but it is unquestionably important as Morris[1] has shown that the shape of the clay cylinder in a pipe press above the die has an important bearing on lamination.

Die Lamination Die lamination is difficult if not impossible to eliminate in all cases but, it is possible to reduce it to practical elimination in most cases. It is due primarily to adhesion and friction between die and clay which retards the flow of the outer portion of the bar causing differential flow.

The larger the die through which the clay is forced the greater the chance for differential flow. For this reason, on account of their smaller cross-section, end cut dies are used on clays which have a tendency to laminate. This reduction of the size of the die is often the

[1] G. D. Morris, *loc. cit.*

only method resorted to by the clayworker or die maker in an effort to solve a lamination problem.

Die Taper Aside from its bearing on the subject of lamination, die taper has an important influence on column speed and power consumption.

The greater the taper, the greater will be the pressure required to force out the column and the greater will be the opportunity for differential flow.

Experiments on hollow tile and brick dies have shown that each clay has a maximum speed taper and that this taper is very small in all cases. Stull[1] working on brick dies found that $\frac{1}{8}$- to $\frac{1}{4}$-inch taper per foot worked best on the clays he experimented with. It is obvious that the taper that will allow a bar to flow with the greatest speed and the least power is the taper that will produce the least lamination.

There is only one method of determining this maximum speed taper and that is by building a die with straight sides of hard wood or soft metal and measuring the speed of the bar under constant conditions. The die will gradually speed up as the clay wears its own taper until a point is reached beyond which it commences to slow down.

The greater the back pressure from the measuring belt or cutter, the straighter may be the die.

Length of Die Long dies are responsible for a great deal of lamination. This is often overlooked. There are scarcely two clays which will work exactly alike in a die of the same length and the same clay will give different results with different water contents or different amounts of pugging.

Highly plastic clays require short dies, in fact, the greater the plasticity the shorter the die, and the shorter the die the less will be the tendency to laminate.

The minimum length of a die for any clay is governed by the speed of the bar. If a die has been correctly designed for a certain column speed an increase in speed will require a lengthening of the die. The principal is illustrated in a short hose nozzle. With the valve slightly opened an unbroken smooth stream will flow but if the valve is opened beyond a certain point, the stream will break up. With a long nozzle this does not occur.

The importance of die length on lamination cannot be stressed too fully. Dies of excessive length are also responsible for other ills. This is especially true of the hollow tile industry in which they are the cause of many difficulties and high losses.

Column Speed Lamination will increase in moderately plastic to plastic clays with increase of column speed. Low speeds produce less differential flow. This is illustrated by large rivers

[1] R. T. Stull, "Flow of Plastic Clay through Dies," *Trans. Amer. Ceram. Soc.*, **11**, 450 (1909).

flowing through flat country. Very little difference is noted in the speed of the current in the middle and near the edges. The same river flowing through a section where it has a good fall will show a tremendous difference.

This accounts for the complaint often heard from clayworkers that trouble with lamination is a new experience. It is usually found that the difficulty has appeared with an increase in production brought about principally by speeding up the auger machine.

Lamination Bars and Cores These are bars or cores or a combination of the two placed in front of the auger. They are intended principally to break up the spiral motion caused by the auger but in some cases to slow up the center of the column. There is no question but that this expedient serves its purpose in some instances but their use always increases power consumption and never strikes at the root of the trouble. In practically every case where used some other and better means can be found.

Lubrication The object of lubrication is to reduce external adhesion and friction. It is generally looked upon as the cause of or cure for lamination difficulties but there is a question as to whether it should be considered of primary importance in many cases. Hollow tile and sewer pipe of the highest quality, free from lamination, are made on dry dies. However, lubrication does greatly aid in producing a perfect column.

The four principal lubricants available are: (1) steam, (2) water, (3) oil, and (4) soap compounds.

Of these, steam and water are the most efficient. Steam has the advantage over water in keeping the die hot, thus providing a film of vapor between clay and steel. The efficiency of this can be judged by sliding a piece of pugged clay over the surface of a piece of hot iron.

The steam or water pressure maintained is very important. Stull[1] found that a die with a half-inch taper and lubricated with water required 60 pounds pressure for perfect results. When the taper was reduced to zero only 25 pounds pressure was required. In using oil, cases have been encountered where pressures up to 250 pounds per square inch have been necessary for best results. Instances are on record where increasing the pressure on the lubricant has entirely eliminated differential flow. In many cases where trouble is encountered a large part of the lubricant circulates around the die because the pressure is sufficient to force only a portion of it to the surface of the bar.

Full steam pressure from the boilers is seldom if ever necessary and in order to get a sufficient volume at the proper pressure and not mark the surface of the bar a reducing valve in the line is necessary.

[1] R. T. Stull, *loc cit.*

Generally more lubrication is necessary at the corners of the die to prevent dragging. This is accomplished in dies of the Niedergesaess type by the shape of the fins which reduce the feed as the center is approached. In dies that feed the same amount of lubricant all around it is necessary to open out the inside corners so as to admit more clay and greater pressure in these areas.

Grinding As lamination most seriously affects the manufacture of shale products such as paving brick and sewer pipe and as shape of the clay grain has been shown to have an important bearing on internal friction the method of grinding has an influence on differential flow. Smooth, flat grains lubricated with water and air materially reduce internal friction while sharp angular grains increase it, which is desirable.

Grinding machines such as dry pans, grinders, and rolls tend to produce grains of a more or less flat shape while those of the impact type produce angular grains. In extreme cases the type of grinding machine is therefore worthy of consideration.

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Raleigh, N. C.

Refractories Bibliographies

YOU have received the third of a series of three bibliographies on refractories. The last *Bibliography* includes a separate index for itself and each of the two previously issued bibliographies.

The first two bibliographies were of a special nature, one being on silica and the other on magnesite refractories.

If you wish the set for binding into a single book the first two will be sent on receipt of ten cents postal coverage.

CERAMIC ABSTRACTS

Compiled by the

AMERICAN CERAMIC SOCIETY

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[1]The abbreviation (*C. A.*) at the end of an abstract indicates that it was obtained from *Chemical Abstracts* by coöperative agreement.

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Abrasives

Abrasive wheels: British regulations. ANON. *Engineering*, **122**, 433 (1926).—The annual report of the British Chief Inspector of Factories contains the requirements in regard to abrasive wheels, and compares them to grindstones. Dust from artificial wheels is less malignant to health than that from grindstones, and is evolved in far smaller quantities, the wheel thus having a much longer life. A number of the largest firms have entirely replaced natural grindstones by such wheels, with economic as well as hygienic advantage. The official requirements are due to the high speed at which the wheels are run, and the danger of bursting. A chart is kept up-to-date showing the position, dimensions, and speed of every machine, and a skilled millwright is responsible for mounting and testing each machine. A standing overall limit of 5000 ft. per minute is put on the speed of any wheel whatever. Attention is called to the inadequacy of many hoods. A hood should not only conduct dust, but should be so substantial and rigidly anchored as to serve as guard should the wheel burst. Imported machines are usually fitted with castiron guards which have been found unreliable. British makers are now using steel guards. H.H.S.

Corundum. C. J. N. JOURDAN. *Commercial and Indus. Gaz.* (Pretoria, South Africa), **1**, 63–65 (1926).—Corundum available as crystal is limited, but so great are the resources in corundum "reefs," that the Union of S. A. could supply the world's demand for an indefinite period by replacing the crystal with the grain corundum. O.P.R.O.

PATENTS

Waterproof abrasive. H. R. POWER. U. S. 1,615,231, Jan. 25, 1927. An abrasive product comprising a flexible backing having abrasive grains attached thereto by a nitrocellulose composition containing a gum.

Abrasive article. M. L. HARTMANN. U. S. 1,615,271, Jan. 25, 1927. An artificial granular abrasive article composed of abrasive grains and a binder and having the pores thereof filled with sulphur.

Cutting-off abrasive wheel. C. R. KING. U. S. 1,616,531, Feb. 8, 1927. A grinding wheel adapted for cutting off lengths of objects comprising a plurality of abrasive disks integrally united and each composed of abrasive grain of substantially equal hardness united by a suitable organic bond, the disks being arranged to form a central zone having each side face covered by a disk in which the grains are united by a weaker bond than those of the central zone, thereby forming a peripheral cutting surface,

the outer portions of which are softer acting and freer cutting than the central portion and form a substantial portion of the wheel periphery and serve to clear the cut during grinding.

Apparatus for applying abrasive to plate glass grinding mechanism. G. W. OAKES. U. S. 1,618,063, Feb. 15, 1927. The method of applying sand to a grinding machine which consists in collecting a measured quantity of new abrasive in a solid mass in a supply hopper located above the machine, washing such abrasive directly to the table in an ungraded condition by supplying water thereto sufficient to provide a relatively thick mixture, rough grinding with such mixture, collecting the abrasive and water from the machine and supplying them to a grader, and thereafter regrading and reusing the abrasive.

Art

A chromium red glaze. CHARLES F. BINNS AND ELEANOR CRAIG. *Jour. Amer. Ceram. Soc.*, **10** [2], 73–74 (1927).—An attempt to make use of the red color of basic lead chromate in a glaze maturing about cone 08.

Colored bodies. CHARLES F. BINNS AND HALLIE E. WARDNER. *Jour. Amer. Ceram. Soc.*, **10** [2], 75–76 (1927).—Experiments were conducted to find a palette of colored bodies which could be worked, and their proper glazes. The formulas obtained are given.

Vital phases of constructive work in clay. MARY E. COOK. *Bull. Amer. Ceram. Soc.*, **6** [2], 48–53 (1927).—The arrival of a constructive era such as follows the destructive eras of wars and darkness shows the great need for a moral, spiritual, mental, as well as commercial development. The latter 2 types of development can be aided by the use of that ideal constructive medium, clay. Efficient schools to aid youth to find itself are necessary. As examples the various schools of France, such as the École Nationale de Ceramique at Sèvres and L'École Nationale D'art Decoratif at Limoges are described, with details as to their object, courses, and requirements of each. E.J.V.

The technique of glass painting. JOSEF STOCKINGER. *Diamant*, **47** [35], 749–51 (1925); **47** [36], 769–70 (1925).—A thorough discussion of glass painting and staining by an artist on that line. The origin of glass painting as an art, flashed glass, colors used, antique red, common colors, kilns used and their construction, and other subjects are taken up. E.J.V.

Chinese pottery. JOSEPH BURTON. *Pottery Gaz.*, **52** [596], 298–301 (1927).—An illustrated lecture dealing with the manufacture of Chinese pottery through the ages, starting 2000 years ago. E.J.V.

The Pewabic Pottery at Detroit—a unique institution. E. B. FLU. *Ceramic Age*, **9** [1], 13–16 (1927).—A history and description of a small, unique pottery in which interesting and original work in pottery and mosaic tile is carried on. Photographs of typical products are shown. A.E.R.W.

Ancient art reproduced in cement. MATTHEW PAXTON. *Rock Products*, **30** [2], 99–100 (1927).—Concrete forms which follow the Mayan and Aztec civilizations of old Mexico are illustrated. F.P.H.

Pittsburgh exhibition brings out new dinnerware shapes and new lines in colored glass ware. ANON. *Ceram. Ind.*, **8** [2], 222 (1927). F.P.H.

Prehistoric American art reborn. E. L. HAMPTON. *Current History*, **25**, 625–34 (1927).—An account of the results of the work of the Carnegie and Smithsonian Institutes, the Peabody Museum, the Archaeological Institute of America, and the Government of Mexico. The first modern adaptations are the Aztec Hotel at Los Angeles and the decorative conceptions of such artists as Mujica and Cornejo. H.H.S.

Baldwin toby-jugs. ANON. *Morning Post*, Jan. 26, 1927.—Prime Minister Stanley Baldwin is the subject of a toby-jug produced by a society of ex-service men known as the Ashstead Potters. The "first edition" is limited to 1000 copies. Queen Mary received No. 1. The jugs are made in pâte-blanche powder blue, or the new "pearl barley" glaze. They cost one pound apiece. H.H.S.

The internal waxing of hollow glass beads. ANON. *Die Perle*, **3**, 40 (1926).—One fault, sometimes found on treating beads with fishsilver, was the formation of bubbles, caused by a too rapid drying of the silver layer or by bubbles in the silvering liquid produced by repeated stirring. Shrinking of the silver layer was noted when the binding agent was too thick, or when water-clear resin solution was employed in a volatile solvent. When, for decorative effects, shrinkage of the silver layer was desired, the effect obtained by rapid drying was too irregular and the following process was then effective. After silvering, the layer was treated for a short time in a bath of 60 parts of 40% formaldehyde and 7 parts of pure alcohol. The drying process was then rapidly carried out without the formation of bubbles. (*Jour. Soc. Glass Tech. Abs.*)

The production of mother-of-pearl decoration effects on glass and artificial pearls. ANON. *Die Perle*, **3**, 40 (1926).—The German patent 570,273 disclosed new methods of treatment to obtain mother-of-pearl effects, and indicated the use of polishes made from Eastern essences. For treatment, preferably, lac was employed with a base of nitrates or acetic acid nitro-celluloses and addition of thickening agents. A suitable coating was obtained by dipping, spraying, or coagulating, and the effect was increased by the use of intermediate layers of resin or other solutions. Special results were produced by addition of a silver essence (as fish silver) to the lac, followed by a particular treatment after drying. A weak cellulose lac served to bring out variations of shade. Albuminous substances soaked with bismuth salts could be used as intermediate layers, and other metallic salts could also be employed. Decoration of the type outlined above was stable both to water and acids. Color effects, cream, rose, green, and blue, were produced by the use of aniline dyes, while a cream tone having a particularly high luster was obtained merely by use of polishing shellac. (*Jour. Soc. Glass Tech. Abs.*)

BOOKS

The Book of Famille Rose. G. C. WILLIAMSON. With 19 plates in color and 43 plates in collotype. London: Methuen & Co., 1927. Price 8 guas. Famille rose decoration is that in which pink made from purple of Cassius is present. It was made either in the reign of Yung Chêng (1723–35) or in that of Ch'ien Lung (1736–1795). The book is reviewed, with reproductions in color of many of the plates, in the *Illustrated London News*, Jan. 29, 1927. H.H.S.

Pottery Worship; the Fallen Idols. M. SOLON. Stoke-on-Trent: The Ceramic Society. Publication by subscription. Reprint of a series of papers read before the N. Staffs Lit. & Phil. Soc., dealing with subjects usually neglected in the general Histories of Ceramic Art, and written by an acknowledged authority. The Secretary asks to be notified by those who wish to purchase copies. H.H.S.

European Glass. W. BUCKLEY. (With foreword by B. Rackham and an Essay on Dutch glass engravers by F. Hudig.) London: Ernest Benn, Ltd., 1926. Price 4 guas. A brief outline of the history of glass making, with notes on various methods of glass decoration. H.H.S.

Islamic pottery. A. J. BUTLER. London: Ernest Benn, Ltd. Price 12 guas. H.H.S.

Report on the investigations at Lubaantum, British Honduras, in 1926. Ed. by T. A. JOYCE. London: The Royal Anthropological Institute. Account of Maya sites

in Central America. The editor is deputy keeper of the Department of Ceramics and Ethmography at the British Museum. H.H.S.

PATENT

Process of coloring glassware. M. L. BURGESS. U. S. 1,615,973, Feb. 1, 1927. The process of producing colored glassware consisting in mixing with each batch a coloring medium in the furnace for coloring the glass throughout the body thereof, rolling the colored molten glass into a substantially flat slab of desired thickness, spraying on the surface while still hot from the rolling operation a solution of copper sulphate and sulphuric acid dissolved and diluted with water, and thereafter passing the glass through an annealing oven for causing the surface coloring produced by the solution to be thoroughly baked and hardened therein.

Cement, Lime, and Plaster

Cellular concrete. ANON. *Rev. Mat. Constr. Trav. Pub.*, **203**, 228–33 (1926).—Description of a product made under patent of Erick Christian Bayer of Copenhagen. Cellular concrete is made by blowing a fluid capable of forming a foam into a concrete mass while in the mixing chamber. The voids formed in the mass are not more than 1 mm in diameter, whereas porous concrete has holes roughly 3 mm in diameter. In the setting the foam evaporates leaving a residue of .01%. The weight per 1 cu.m is from 200 to 1200 kg for cellular concrete, and 2200 kg for ordinary concrete. The heat conductivity varies with density from 0.038 to 0.28, while ordinary concrete has a value of 1.3. Blocks of cellular concrete are strong enough for building houses, and are made with a density of 1; partitions with a density of 0.7. For heat insulation material of density 0.2–0.4 is used. A number of illustrations of these applications, as for refrigerators, boilers, etc., is given. L.N.

Use of lean (poured) concrete in the construction of houses. P. C. *Rev. Mat. Constr. Trav. Pub.*, **201,** 183–85, **202,** 215–18, **203,** 235–37 (1926).—A review of a reprint of the "Commission instituted to study the use of concrete poor in cement for the construction of cheap houses," appearing in the *Annales Trav. pub. Belgique*, Aug. 1925. Chapter I lists the important properties of materials like (1) masonry made of brick, (2) concrete block, (3) masonry of lean poured concrete. It is claimed that a rich cement concrete would not only be too expensive but inappropriate for dwellings, as it forms a mass filled with capillaries which draw moisture. Poured lean cement concrete contains less fines leaving a more porous structure with fairly isolated pores which prevent the passage of water by capillarity and prevent the passage of heat. L.N.

Future Swiss Standards for cement binders used in the preparation of mortars, based on tests made by the L.F.E.M. M. ROS. *Rev. Mat. Constr. Trav. Pub.*, **205,** 293–300 (1926).—Swiss standards for cements were first formulated in 1881, with subsequent changes as indicated. The data were obtained on mortars composed of 1 part cement and 3 parts normal Swiss sand, made in a damp earth condition, tamped by machine and maintained under water.

	NORMAL PORTLAND CEMENT		SPECIAL PORTLAND CEMENT (Initial) high resistance	
Year	Compressive strength Kg. per sq. cm.	Tensile strength Kg. per sq. cm.	Compressive strength Kg. per sq. cm.	Tensile strength Kg. per sq. cm.
1881	—	12	—	—
1883	150	15	—	—
1887	160	16	—	—
1900	220	22	—	—
1919	260	22	—	—
1925	325	28	650	40

The requirements for 1925 are based on the results obtained in the years 1922–24 on 17 brands of normal Portland cement and on 3 brands of special Portland cement by the "Laboratorie Fédéral d'Essai des Matériaux." (L.F.E.M.) The average values obtained and the prescribed standard values are given for 3, 7, and 28 days of aging.

	Normal Portland Cement				Special Portland Cement			
	17 brands Years 1922–24				3 brands Years 1922–24			
Days	Compressive strength Kg. per sq. cm.		Tensile strength Kg. per sq. cm.		Compressive strength Kg. per sq. cm.		Tensile strength Kg. per sq. cm.	
	Av.	Stand	Av.	Stand.	Av.	Stand.	Av.	Stand.
3	248	—	27	—	414	325	35	28
7	340	230	30	20	580	500	43	35
28	453	325	37	28	715	650	48	40

Numerous graphs are given to illustrate the individual values obtained for all 20 cements for the properties—compression, tension, density, % water for tempering, time of set. It is maintained that the Swiss products rank among the best in the world. Fused aluminous cement is made by a company at Bex, the chemical composition being SiO_2 3.81%, Fe_2O_3 5.27, FeO 9.07, Al_2O_3 42.60, CaO 32.64, $CaCO_3$ 2.27, MgO 0.26, water 0.49, insoluble 3.66. Results determined in the years 1921–23 on 30 fused cements by L.F.E.M. on mortars 1 : 3, tamped and maintained under water are:

Fused Aluminous Cements

Days	Compressive strength Kg. per sq. cm. Av. of 30 tests	Tensile strength Kg. per sq. cm. Av. of 30 tests
1	570	30.1
2	667	33.0
3	724	36.0
7	814	39.5
28	890	40.4
90	909	40.5

For future work it is planned to collect data on the following properties: (1) sp. gr.; (2) weight of a unit of volume, (3) duration of set (should be known to regulate working time), (4) heat developed on setting. In some massive walls a heat rise of 30°C was obtained. It is essential in working fused cement to make provision for the escape of heat, (5) fineness of grind, important in developing hydraulic qualities, (6) stability of volume in hot water and in hot dry air, (7) loss on ignition to determine water and calcium carbonate contents (both being usually not desirable), (8) resistance to compression and tension of 1 : 3 normal mortar for 7 and 28 days of aging, (9) compressive strength increase of plastic mortar as compared with tamped mortar, as the plastic mortar increases more rapidly in strength than the tamped (after 3 days).

Compressive Strength (1:3 Normal Mortar)

	Plastic		Damp	
Days	Kg. per sq. cm.	Per cent increase	Kg. per sq. cm.	Per cent increase
1	8	—	35	—
3	90	0	201	0
7	164	84.7	297	47.8
28	269	199.	426	112.

(10) contraction with time, determined on prisms 12 x 12 x 36 cm, maintained in a humid atmosphere, made with special Portland cement, mortar 475 kg cement and 1 cu.m sand, 11% water (plastic method); the concrete made with 250 kg cement with 1 cu.m of sand and gravel (1 : 2), 7.2% water (plastic method).

PER CENT CONTRACTION

Days	Mortar	Concrete
2	0	0
7	0.197	0.051
28	0.292	0.136
84	0.340	1.160
210	0.367	0.172
365	0.374	0.196

(11) elasticity of prisms of concrete, 12 x 12 x 36 cms. Ordinary Portland cement, 250 kg cement and 1 cu.m of sand and gravel (1 : 2), 6.5% water (of dry weight of materials).

PER CENT SPECIFIC ELASTIC CONTRACTION

Pressure applied kg. per sq. cm.	28 days	60 days
60	0.166	0.146
100	0.328	0.264
140	0.5	0.416

(12) variations in properties of a cement made by each concern over a period of time. (13) the extreme values for the hydraulic modulus, and content of insoluble residue, gypsum and magnesia by chemical analysis. L.N.

Standard specifications and tests for Portland cement. *A.S.T.M. Stand.*, 32–50(1926), Ser. Desig. C 9–26.—Under these specifications are given 5 sections as follows: chemical properties; physical properties; packing, marking and storage, inspection; rejection. Each section gives in detail the requirements of the specifications. Nine additional sections are devoted to methods of tests as follows: sampling; chemical analysis; determination of fineness; mixing cement pastes and mortars; normal consistency; determination of soundness; determination of time of setting; tension tests; and storage and test specimens. R.A.H.

Standard specification for quicklime for structural purposes. *A.S.T.M. Stand.*, 51–53(1926), Ser. Desig., C 5–26.—Under these specifications are given 3 sections as follows: requirements; methods of test; sampling, retesting, packing and marking. Each section gives in detail the requirements of that portion of specifications to which it refers. An appendix is given describing the preparation of lime putty. R.A.H.

Portland cement research. R. H. BOGUE. *Proc. A.S.T.M.*, **26** [2], 403–13(1926). —B. discusses principal of fundamental research as applied to the study of Portland cement and the need of this type of research rather than the collection of empirical and statistical data. Scientific and engineering points of view are analyzed as well as the research requirements in Portland cement. B. also discusses the various investigations of the Portland cement fellowship now under way at the Bureau of Standards. Studies have been made on the systems lime–alumina–silica; lime–ferric oxide–silica; lime–iron oxide–alumina. Details are given of line of attack and some of the apparatus necessary in this work. R.A.H.

Coöperative checking of cement testing. S. R. MITCHELL. *Proc. A.S.T.M.*, **26** [2], 414–16(1926).—M. advocates more reliable cement testing in every phase. Cement testing methods produce very erratic results in hands of careless or inexperienced testers. Discusses variations in results of several laboratories due to such factors as faulty apparatus; effect of turning briquet molds; effect of abnormal consistency; defective sieves; errors in chemical analysis; factors affecting soundness test; tension and compression testing; and how these variations were remedied. R.A.H.

The autogenous healing of concretes and mortars. H. J. GILKEY. *Proc. A.S.T.M.*, **26** [2], 470–87 (1926).—The general conclusions from all the tests made is that autogenous healing action follows the same general law as uninterrupted strength gain from continuous moist curing. Specimens salvaged without much visible damage will often develop strengths approximately 100% of what they would have had without previous tests. Healing takes place to some extent in even badly shattered specimens, but full former strength may not be attained. A number of graphs are given. R.A.H.

Plasticimeter base plates for the Emley plasticimeter. ANON. Bur. Stand., *Tech. News Bull.*, No. 117, pp. 1–2 (1927).—A description of method of measuring plasticity of lime with this plasticimeter is given. Variations in plasticity values have been found to be due to rate of absorption of base plates which were found to absorb water at greatly varying rates. Work is being done which will lead to specifications embodying a "rate of absorption" requirement. R.A.H.

Silicates in Portland cement. P. H. BATES. *Eng. News Rec.*, **98** [3], 121 (1927).—A discussion on the principal constituent of clinker. A difference of opinion between Americans and Germans as to whether this constituent is tricalcium silicate or dicalcium silicate has finally been decided, after 2 years of research, in favor of the former. R.A.H.

Certain cements and their properties. J. F. GODDARD. *Can. Eng.*, **51** [24], 710–12 (1926).—Characteristics of Portland cement and method of manufacture discussed. Waterproofing of cement by the addition of catacoll. Process of hydration of the various constituents of cement is noted. R.A.H.

Securing high early strength from ordinary Portland cement. H. S. VAN SCOYOC. *Contract Rec. and Eng. Rev.*, **40**, 75 (1926).—While the percentage of work in which high early strength is the important factor will always be relatively small in comparison to total amount of concrete construction, there are certain fields in which it is both beneficial and economical. It insures satisfactory construction in cold weather; the making of repairs to paving on important streets and thoroughfares is another opportunity for the use of high early strength concrete. The closing in of short stretches of highway which have been left unpaved on account of unsettled fills at bridge approaches, the paving or repaving of tramway allowances, the building of foundations for machinery, and also for other fields which suggest themselves. Calcium chloride as an admixture is recommended by V. S., but care must be taken that the calcium chloride is free from magnesia or bleaching powder. Results vary with the chemical and physical brands of Portland cement; it is therefore well to try out any particular brand by some preliminary tests. If certain definite principles are followed out in addition to the methods ordinarily employed in the making of good concrete quite high early strength can be secured. (1.) Use calcium chloride in an amount equal to 2% by weight of the weight of cement. (2.) Use a low water-cement ratio. (3.) Place the concrete at a temperature as near 70°F as possible. (4.) Mix the concrete for at least 2½ minutes after all materials have been added. (5.) Cure the concrete in a moist atmosphere as near 70°F as possible. The best way to use calcium chloride is to dissolve 100 lbs. in 25 gals. of water and add ½ gal. of this solution for each sack of cement in the batch. A gain in strength of 50% in 24 hrs. and 30% in 7 days should be secured. A strength of 2,000 lbs. per sq. in. in compression at the end of 24 hrs. should be obtained. O.P.R.O.

The Calaveras Cement Company's new wet-process plant. ANON. *Rock Products*, **30** [2], 34–39 (1927). F.P.H.

Work of the nonmetallic mineral station of the Bureau of Mines during 1926. OLIVER BOWLES. *Rock Products*, **30** [1], 34–36 (1927).—Some of the problems studied are as follows: (1) effect of steam in the lime kiln, (2) an X-ray study of limes having

different plasticities, (3) lime burning with sintering machine, (4) quarry problems in the lime industry, (5) mining and utilization of mica, (6) properties of bentonite, (7) the concentration of low-grade bauxite ores. F.P.H.

Recent research developments in field of rock products. S. S. STEINBERG. *Rock Products*, **30** [1], 51–53 (1927).—A short description of the investigations being conducted by federal bureaus, colleges, and associations on the study of cement, concrete, and lime. F.P.H.

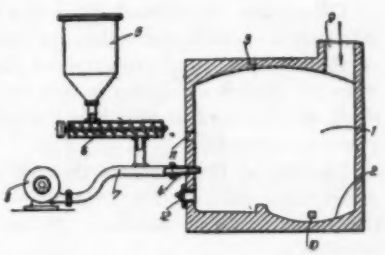
Note on aluminous or fused cement. J. BOLOMEY. *Bull. techn. suisse rom.*, **52**, 120–21 (1926); *Chimie et industrie*, **16**, 795 (1926).—Setting of aluminous cements begins in 2–3 hrs. and is complete 3–5 hrs. later. Unlike that for ordinary cement, the time required for setting increases with rise in temperature (2 hrs. 50 min. at 20°, 3 hrs. at 26°, 5 hrs. at 30°). Setting is considerably affected by addition of small quantities of CaO, cement, or other substances containing free CaO: with increase in the proportion of CaO the rate of setting and the evolution of heat increase while the strength rapidly increases with age and finally is completely destroyed. (*C. A.*)

BOOK

The making and testing of Portland cement and concrete. G. and T. EARLE. Hull: G. & T. Earle Co., Ltd., 1926. Price 10*s*. H.H.S.

PATENT

Process for the manufacture of fused cement and apparatus therefor. GEORGES DUMAS. U. S. 1,615,260, Jan. 25, 1927. Process of obtaining fused cement in reverberatory furnaces, particularly aluminous cement, which comprises continuously feeding cement forming materials on to the hearth of a reverberatory furnace, from a substantial distance thereabove, melting the materials by impinging burning fuel thereon, and allowing the fused cement to flow away.



Enamel

Notable enameling plants at Detroit. ANON. *Ceramic Age*, **9** [1], 7–12 (1927).—A description, with photographs, of the rapid-production methods and equipment used in 4 interesting enameling plants in Detroit. A.E.R.W.

Continuous furnace enamels 500,000 pieces per month. ROBERT MCDOUGALL. *Ceram. Ind.*, **8** [2], 209–11 (1927).—A description of the Beemack continuous drying and firing furnace. F.P.H.

Blowers cut fuel cost 25%. L. S. WEIMER. *Ceram. Ind.*, **8** [2], 212–15 (1927).—A description of the enameling plant of the Malleable Iron Range Co. F.P.H.

Twelve commercial enamel batches. F. M. BURT. *Ceram. Ind.*, **8** [2], 216–18 (1927). F.P.H.

Modern trend in enamel kitchen equipment. ANON. *Ceram. Ind.*, **8** [2], 218–20 (1927). F.P.H.

Enamel colors. E. O. RASSER. *Kunstoffe*, **16**, 218–20, 246–48 (1926).—The technic of glass painting with enamel colors is outlined. Compositions of fluxes and various colored enamels of proven merit are given. (*C. A.*)

BOOKS

Brushings. Edited by William Feather and published monthly by the Ferro Enamel Supply Co. of Cleveland, Ohio. An interesting house-organ. Subscription price $1.00 per year, free to members of the porcelain enameling industry.

Enamelers' Training Course. A complete outline of practical and theoretical study of the art of porcelain enameling. Published by The Ferro Enamel Supply Co. of Cleveland, Ohio. The course is under the direction of J. E. Hansen and H. C. Leubbert. Free copies of outline may be secured by writing the Ferro Enamel Supply Co., 2100 Keith Bldg., Cleveland, Ohio.

Glass

Crown flues preheat glass tank air. ANON. *Ceram. Ind.*, **8** [2], 170(1927).—A description of a new tank at the plant of the Technical Glass Co. There is no regenerator attachment but there are 11 parallel courses of Argon brick in the crown which is perforated with a hole through its longest measurement; making as many tubes or flues running the entire length of the crown. At the discharge end of the tank, air is forced into these tubes by a fan which exerts a pressure of 2 oz. per sq. in. This air is heated during its passage through the flues in the crown of the tank, and is discharged into the opposite end of the combustion chamber where it enters into a mixture with the natural gas. A constant temperature within the combustion chamber is claimed for this type of construction. F.P.H.

Calculation of physical properties of glass. S. R. SCHOLES. *Ceram. Ind.*, **8** [2], 200(1927).—Scholes states that the theory that the influence of each component oxide on the several physical properties of glass is additive, is only applicable to new glasses when the glasses are similar in type to those from which the factors were originally derived. It is suggested that it is the compounds present that are responsible for variations in properties. F.P.H.

Looking at the universe through rose-colored glassware. GEORGE S. COOPER. *Amer. Glass Rev.*, **46** [19], 15(1927).—The predominance of rose-colored glassware at the present time is discussed. A formula for making rose glass published in 1908 is as follows:

Sand	50 kg.	Lime	6 kg.
Potash	10 "	Saltpeter	2 "
Soda	6 "	Borax	1 "
Red lead	5 "	Metal selenium	200 g.

A fairly representative present day batch is as follows:

Sand	1000 lbs.	Burned lime	110 lbs.
Soda ash	200 "	Arsenic	2 "
Potassium carbonate	200 "	Borax	5 "
Niter	30 "	Selenium	10–16 oz.

E.J.V.

Some aspects of glass tank practice. FRED S. THOMPSON. *Amer. Glass Rev.*, **46** [20], 15–16(1927).—A preliminary report to be published in full in an early issue of the *Journal of the American Ceramic Society*. E.J.V.

Influence of character of fire in continuous tank practice. IRVING E. ADAMS. *Glass Industry*, **8** [2], 25–26(1927).—Conditions observed in several glass plants showing variations in character of the fire and the glass produced are enumerated. The use of a soft luminous flame in gas fired tanks gives best results in the production of goo glas free from the usual defects. E.J.V.

Iron and its compounds as coloring agents for glass. ERICH FELSNER. *Glass Industry*, **8** [2], 29–31 (1927); translated from *Keram. Rund.*, **34** [50], 818 (1926).—The various iron compounds which may be used alone or in combination with other materials as coloring agents for glass are discussed. The important property of iron in that it is capable of producing a variety of colors when used in different quantities is mentioned. Forty-two batches of colored glass using iron are given. The character of the glass batches is indicated by means of figures as follows: (1) potash glass, (2) soda ash glass, (3) potash-soda ash glass, (4) salt cake glass, (5) milk glass, (6) cryolite glass, (7) bone ash glass, (8) potash-lead glass (heavy), (9) potash-lead glass (light), (10) potash-soda ash-lead glass. Based on 100 kilograms of sand and with the quantities given in kilograms, a few of the batches of colored glasses are as follows:

Batch No.	Green ruby	Amber	Antique green	Antique yellowish brown	Agate red
	1	2	3	4	5
Fe_2O_3	4	2	2	2.25	1
Cu_2O	—	—	—	—	4
CuO	6	—	—	—	—
$CuSO_4$	2	—	10	—	—
SnO_2	—	—	—	—	4
MnO_2	—	7	—	6.5	—
K_2CrO_4	2	—	0.4	—	—
Tartaric acid	—	—	—	—	2

Batch No.	Imperial red	Antique Coffee brown	Imperial red	Aventurine
	6	7	9	10
FeO	0.5	—	—	—
Fe_2O_3	—	—	0.2	4
Fe_3O_4	—	0.8	—	—
Cu_2O	1.5	—	2.5	5
SnO	0.25	—	—	—
SnO_2	—	—	—	2.8
MnO_2	—	8	2.5	—
Tartaric acid	1	—	—	—

E.J.V.

Produces ultra-violet transmitting glass. P. H. JENNINGS. *Glass Industry*, **8** [2], 33 (1927).—A brief description of Vitaglass and data regarding its use in schools and in zoos on account of its therapeutic value are given. E.J.V.

The Society of Glass Technology. ANON. *Pottery Gaz.*, **52** [595], 107–11 (1927).—Three of five papers read at the meeting on December 15, 1926, are given in considerable detail. In "Some Corrosion and Erosion Phenomena," J. H. Hyslop, R. Gumm, and H. Biggs emphasize the importance of the macrostructure of refractories in connection with corrosion and erosion phenomena. Data were given which showed that the disintegration in a solvent of a composite material, such as wax loaded with fired clay particles, depended on 2 factors: (*a*) the density of the solute rich layer relative to the solvent, (*b*) the size of the particles. If a light upward flowing layer was formed the material with large particles would be more rapidly broken up than that containing small particles. The reverse holds if a dense downward flowing layer is formed, the finer the particles the more rapid being the corrosion. Laboratory experiments confirming these statements were cited, using clay rods immersed in a lead glass and in a soda-lime glass. The former corroded the clay with larger grog in it while the latter attacked the finer material. It was also shown that where erosion was the principal factor in the break up of the refractory the conditions demanded different characteristics in the grog in that the material must hold the maximum of fine particles. In "X-Ray Patterns of Mullite and Sillimanite," by J. F. Hyslop and H. P. Rocksby, further data

for several alumina-silica materials is recorded. It is reported that by paying attention to the necessary technique consistent results were obtained. It was concluded that there were, on close inspection, real and consistent differences between the patterns of sillimanite and of the crystalline substance formed in the samples examined. These differences, though small, had been found sufficient for identification purposes, since they did not depend on differences in intensity which could be caused by preferential orientation of the crystals, but on the relative spacing of the lines. "Sillimanite as a Glass Works Refractory," by W. E. S. Turner, was a report on the progress in regard to the investigation of this subject. A pot ring of 5 parts fine, 1 part medium, and 1 part coarse sillimanite, with 3 parts ball clay showed little sign of attack by the glass after being in service for 10 weeks in a pot melting a potash–lead oxide–silica type glass. A sillimanite pot, holding 30 pounds of glass, which had been in use for melting a series of soda–ferric oxide–silica glasses stood up well, exhibiting no signs of honeycombing though sillimanite usually offered little resistance to the attack of iron oxide-bearing ash. An example of the great resistance offered by sillimanite to changes in temperature is also cited. Two other papers read were: "Parison Molds," by S. English. and "The Viscous Properties of Glass," by W. H. Stott. E.J.V.

The transmission of light by window glass. A. K. TAYLOR AND C. J. W. GRIEVESON. *Pottery Gaz.*, **52** [595], 131 (1927).—It is pointed out that the daylight illumination at any point in a room of definite design depends on 3 factors: (*a*) the brightness of those parts of the sky and other bright surfaces which are visible from the point in question; (*b*) the amount of light transmitted by the glass in the window; and (*c*) the reflecting power of the walls and ceiling of the room. The second of these factors is discussed and measurements made at the National Physical Laboratory with the object of determining the transmission factors, under various conditions, of a number of different kinds of glass commonly used for the windows of domestic and industrial buildings are described. E.J.V.

The Society of Glass Technology. ANON. *Pottery Gaz.*, **52** [596], 277–82 (1927).—W. E. S. Turner's paper "The Present Position of the Glass Trade in Germany" takes up (1) the distribution of the industry, (2) types of glass produced, (3) the fuel problem, (4) natural raw materials, (5) changes since the war, (6) amalgamations of small companies, (7) electric light bulbs, (8) bottle glass, (9) low temperature carbonization, (10) attitude of the workers, (11) German Society of Glass Technology, (12) increasing technical activity, (13) some important technical schools, (14) provision for research, and (15) competition with England. J. F. Ponomareff, in his paper "Developments in the Glass Industry in Russia," discusses (1) factories closed by the revolution, (2) need for machinery, (3) research institutes, (4) raw materials, and (5) lack of English propaganda. E.J.V.

The silvering of plate glass. F. ELLERMAN AND H. D. BABCOCK. *Diamant*, **47** [33], 712–13 (1925); **47** [34], 729–30 (1925).—A review of methods of silvering glass, starting with methods used in 1897 and continuing to those now in vogue. Details of various methods are given. E.J.V.

Artificial jewels. H. v. B. *Diamant*, **47** [34], 730–31 (1925).—A description of methods of producing artificial jewels as practiced by the Egyptians and later developed, as time went on, to what is now an art. Mention is made of some of the compositions used in making this artificial jewelry. E.J.V.

The development of the German glass industry. FRITZ HAUBOLD. *Diamant*, **47** [36], 767 (1925).—The mechanical production of glass and development of various types of glass-working machinery are discussed. E.J.V.

Flint glass show notes. ANON. *Nat. Glass Budget*, **42** [39], 7(1927); *Pottery, Glass and Brass Salesman*, **34** [24], 11(1927).—Short descriptive sketches of exhibits at the Annual Pottery and Glass Exhibit in Pittsburgh. E.J.V.

Bellaire as glass center. JAKE CRIMMEL. *Nat. Glass Budget*, **42** [39], 9(1927); reprinted from *American Flint*.—An interesting article of historical value, relative to Bellaire, Ohio as an early glass center. E.J.V.

What is Vita glass? ANON. *Nat. Glass Budget*, **42** [39], 21(1927).—A description of this new glass which is of great therapeutic value due to its power to transmit the ultra-violet or actinic rays. The forms in which it is produced are discussed. E.J.V.

Some observations on heat transfer in furnaces. D. J. MCSWINEY. *Nat. Glass Budget*, **42** [40], 10(1927); *Amer. Glass Rev.*, **46** [18], 15–16(1927); reprinted from *Jour. Amer. Ceram. Soc.*, **10** [1], 1–5(1927). See *Ceram. Abs.*, **6** [3], 96(1927). E.J.V.

Merits of actinic glass. L. T. SHERWOOD. *Nat. Glass Budget*, **42** [42], 3(1927).—In setting forth the merits of actinic glass, S. states that it will: (1) in various ways greatly reduce glare, (2) materially reduce the radiant heat in direct sunlight, (3) greatly retard quite a number of undesirable chemical changes, such as the fading of colors, and (4) on dark days, produce illuminating effects more like pleasantly diffused sunlight than the somber light from the sky. E.J.V.

Sodium sulphate in the glass industry. L. H. COLE. Canada Dept. of Mines. Mines Branch, pp. 41–43, 1926.—Sodium sulphate, as a source of alkali, is extensively used in glass manufacture; in the production of sheet and plate glass of all kinds the alkali required in the batch is frequently introduced in the form of salt cake, a relatively crude product, generally obtainable at a much cheaper rate per unit of Na_2O than soda ash. Its use has certain disadvantages; silica alone cannot decompose the salt cake. The reducing agent generally employed is some form of carbon such as charcoal, coke, or powdered anthracite coal. Since the use of a slightly incorrect quantity of carbon is liable to lead to loss of the whole batch, highly skilled labor is required to tend the furnace tank when salt cake is used. Another difficulty is the removal of all traces of sulphur compound from glass made by this process, this requires great care that high quality of glass be produced. Commercial by-product salt cake, when powdered and exposed to the air absorbs a certain quantity of moisture, with result that part of it is converted into Glauber's salt thus hardening the material, which necessitates regrinding before use. Fine grinding is exceedingly difficult. Advantages in substitution of salt cake for soda ash are: higher temperature is required in the tank and in consequence a greater proportion of silica sand can be employed, thus reducing the cost of the batch. Frink observed that glass made with salt cake, furnace conditions being the same, is harder, has a higher softening-point, greater strength and is less viscous at 845°C than that containing soda ash, although analyses showed that their composition was practically the same. Gelstharp and Parkinson found that sodium sulphate must be present in order to successfully produce glasses containing more than 8% of lime. Definite specifications for salt cake in glass manufacture are difficult. It is employed in glass-making to supply Na_2O to the batch, and therefore any impurities, while they may not affect the quality of the glass in themselves, reduce the amount of available Na_2O content in the salt cake. O.P.R.O.

Effects of thermal treatment on glass as shown by precise viscometry. V. H. SCOTT, D. TURNER, AND H. A. SLOMAN. *Proc. Roy. Soc.* (London), **112A**, 499–521 (1926).—A viscometer must be constructed of a material which is insoluble in molten glass; this permits the glass to be tested, to be cooled to room temperature and reheated; prolonged thermal treatment can be followed with this apparatus. The viscosity is

measured by determination of the thickness of the film of glass which adheres to a thin wire of 10% iridio-platinum, which is withdrawn at a known velocity from the molten glass contained in a small crucible of the same material. The glass is heated in a vertical Pt resistance furnace; the true temperature is obtained by comparing in a separate experiment the readings of the optical pyrometer with those of a thermocouple. The values of the viscosity at different temperatures are given in the following equation: $\log (k\eta) = \log \{ (t/a)[(\gamma + n)/v] \} + C[0.8 - (t/a)]$, where η is the viscosity of the glass; t the thickness of the glass deposit; a the radius of the wire; v its velocity of withdrawal; γ surface tension of the glass; n is a quantity, small compared with γ, expressing the influence of gravity; the value of t is selected so that t/a differs little from 0.8 in order that the last term shall be small. In case of any one glass, once homogeneity has been attained at a high temperature, the viscosity value is reproducible within $\pm 3\%$ at a temperature of 1200°. The viscosity at temperatures above 1200° is unaffected by cooling the glass to room temperature and reheating, provided that the glass is not held too long within a certain range of critical temperatures below 1200°. At temperatures below 1200° it appears that the glass is capable of existing in at least 2 states resulting in considerable variations of viscosity. The mean viscosity in this case is that which would be anticipated from an extrapolation of the viscosity-curve from temperatures above 1200°. In certain circumstances it is possible to obtain the glass at temperatures below 1200° in a metastable state similar to its state at high temperature. In this case the curve is continuous. The theory of the new viscometer is given.

(*C. A.*)

Investigations on opalescent glasses. A. GRANGER AND M. BABILLE. *Chimie et industrie.* **Special No.,** 509–12 (Sept. 1926).—A brief critical review of theories of the mechanism of opacification. (*C. A.*)

The annealing of glass. F. W. PRESTON. *Trans. Opt. Soc.,* (London) **26,** 274–77; Disc. 277–80 (1924–25).—On the assumption that the coefficient of expansion of glass is constant over the annealing range and that Twyman's law connecting viscosity with temperature accurately represents the facts over the same range, it is concluded that Hampton's results are correct and his numerical values calculated from satisfactory premises. See also *Ceram. Abs.,* **5** [5], 149 (1926).

Ivoit—a new artificial material for the bead industry. ANON. *Die Perle,* **3,** 43 (1926).—The new glass substitute "Ivoit," discovered by F. Pollak, was recommended as a suitable material for making beads, buttons, etc. It was supplied in blocks of a size 110–160–270 mm or rods 80 cm long and 6–50 mm diameter. (*Jour. Soc. Glass Tech. Abs.*)

Phonolith in glass manufacture. W. LIEBIG. *Sprechsaal,* **59,** 284 (1926).—L. agreed with the opinion, expressed by previous writers, as to the advantage of using phonolith, and quoted the case of a large bottle factory which had used it for 18 years. Analyses of Westerwald and Kaiserstuhl phonoliths were given, these containing 9.83% and 10.6% of alkali, respectively. For machine-made glass, the phonolith content of the batch should not be too high, a reasonable amount being some 125% of the sand quota. (*Jour. Soc. Glass Tech. Abs.*)

The testing of milk bottles. F. W. KOUWENHOVEN. *Glass Ind.,* **7,** 137 (1926).—It was desirable to use milk bottles as often as possible before breakage, and this entailed repeated cleansing which occupied about 45 minutes, during which the bottle was washed, heated to sterilization point, and then cooled to the temperature of refrigerated milk. In the compression test, K. had placed the bottles vertically; but he obtained results varying from 2400 lbs. to 6200 lbs. load. Therefore this method was discarded. He then used three bottles placed horizontally one above the other in the machine; the middle bottle always broke, but the average load for fracture was 978 lb. for ten tests,

and the variation was large. In testing the necks, it was found that a "supported curve" type of head was stronger than the common type, needing a breaking load of about 1350 lbs. against 1125 lbs. for the common types. The internal hydrostatic test was very useful, the average pressure required to fracture 82 quart bottles being 185 lbs. per sq. in. In temperature tests, it was found that usually the bottles would withstand a rise in temperature from atmospheric of 170°F (85°C); but in cooling from 130°F (60°C) they would withstand a fall in temperature of 88°F (55°C); cooling from 150°F (75°C) a fall of 85°F (53°C), and cooling from 210°F (110°C) only 80°F (50°C). This test also indicated faulty design in either necks or bottoms. Tapping tests served to indicate faulty designs in the abrupt angles which sometimes occurred; the "supported curve" was certainly better than the abrupt curve. By re-designing some of the bottle necks to give a "supported curve" it has been possible to reduce breakage due to chipped necks from 70% of the total breakage almost to zero. (*Jour. Soc. Glass Tech. Abs.*)

Storage effects on sheet glass. ANON. *Sprechsaal*, **59**, 156 (1926).—It was dangerous to store sheet glass in a damp place, since weathering was then likely, particularly in the case of glass rich in alkalis. Where sheets were so packed, face to face, moisture condensed between the sheets in patches, due to surface irregularity (this did not occur with polished plate), and attack then occurred. In these circumstances, attack was worse than when the glass was in use, since there was no drying action of sun and wind. When first formed, the spots could be removed by washing, but as attack developed the marks became permanent. (*Jour. Soc. Glass Tech. Abs.*)

The nature of the polishing operation. F. W. PRESTON. *Trans. Opt. Soc.*, **27**, 183 (1925–26).—While Sir George Beilby estimated the flowed layer in glass as probably 25–50$\mu\mu$, J. W. French interpreted some of his results as indicating a layer about 8μ. Various other conclusions served to show the unsatisfactory state of the current views, and P. endeavored to examine the problem with the object of bringing out the relevant phenomena as follows. Abrasives from their properties seemed to act by their ability to concentrate high pressure on small areas and so presumably to crush and fracture the glass surface. Since some substances fluoresce in the crystalline, but not in the amorphous condition, an amorphous flowed layer on polished glass might be thus detached. A flowed layer on calcite was supposed to be much tougher than the under surface, but by weighing the material removed under controlled conditions of polishing no signs of a progressive toughening of a glass surface could be found. Ground glass possessed double refraction which disappeared on polishing, but the finer the abrasive the slighter the double refraction, and as the polishing abrasives only removed glass at one-fiftieth the rate of those used for fine grinding, it might be that the difference was only one of degree. If a very small but still measurable surface compression did not exist, it would weigh heavily against the surface flow theory. Very slight etching of a polished surface revealed detail consisting chiefly of chatter-flaws which could not exist if the flowed layer were more than a few $\mu\mu$ deep. If there were a deep surface layer it should be possible to find the loss in weight necessary to lay bare these "chatter-flaws." While the diameter of the chatter "sleeks" should be proportional to the diameter of the grain producing them, it was found that the small grains produced proportionately wide sleeks, possibly wider than themselves, and in this case the adjacent grains in the well-charged polishes would tend to set up flaws opposing one another and produce complications which might account for the inefficiency of the polishing process (about 1%) as compared with the grinding processes. While flow was discernible with a felt polisher and dry rouge and with abrasive wheels, where a high local temperature was developed, yet the best polish was obtained under conditions preventing such high

temperature developing. Refractive index, interfacial tension, and electrostatic tests all gave negative results. X-ray methods did not appear to have been worked out. From the production of "enamels", that is high spots as shown by interference tests, of about one-sixth λ which were insoluble in all acids but hydrofluoric acid, it seemed possible that glass in polishing was removed in particles of about this size, and when the surface became too hot (the condition favoring enamel formation) some became stuck to the glass again. Thus the evidence for the existence of a flowed layer in polished glass appeared to be slight or negative. (*Jour. Soc. Glass Tech. Abs.*)

Influence of the glaze on some physical properties of porcelain. E. GEROLD. *Mitt d. Hermsd. Schomb. Isol. G.m.b.H.*, No. 15; *Z. Instr.* **46,** 158 (1926).—A series of experiments was carried out to determine the influence of various glazes on the tensile strength, the bending strength, and the transverse strength of porcelain. The results showed that some glazes have the effect of increasing the mechanical strength, while others lower it. Results were also given showing the relation between the strength and the thickness of the glazed layer for three different glazes. As the glaze was removed (by heating in a blowpipe flame), the strength gradually approached that of the original unglazed porcelain. No information was given as to the nature of the glazes employed. In another series of experiments, measurements were made of the effect of applying the same glaze to two different clays. The difference in the strengths of the unglazed material amounted to about 30% of the lower value. The application of various glazes reduced this difference to 14, 5, 4, 10, 6, and 8% respectively. The influence of the glaze on the temperature coefficient and on the thermal endurance was also examined. It was found that, for unglazed porcelain, a satisfactory agreement was obtained between the experimentally determined values and those calculated by means of the Winkelmann and Schott formula, whereas such an agreement was not found for glazed porcelains, since their mechanical properties were dependent on the nature of the surface layer. (*Jour. Soc. Glass Tech. Abs.*)

On the change in the coefficient of expansion of substances in the amorphous state. M. SAMSOEN. *Compt. rend.*, **182,** 517 (1926).—Many organic compounds differing widely in chemical properties, were found to exhibit an increase in the coefficient of expansion when the temperature was such that the viscosity reached some 10^{14} poises. This anomalous behavior had previously been thought to be peculiar to silicates, borates, and phosphates, but was now proved to characterize all substances in the amorphous state. This anomaly in the value of the coefficient of expansion was always accompanied by changes in all physical properties in the case of silicates as shown by many workers, but had wrongly been attributed to an allotropic change in silica. It was a property common to all substances in the amorphous state. (*Jour. Soc. Glass Tech. Abs.*)

The calculation of glass constants in the form of individual functions of the oxides in given fundamental glasses. E. ZSCHIMMER. *Sprechsaal*, **59,** 249, 265, 282, 297 (1926).—The advantage of being able to calculate the properties of a glass from a knowledge of the composition of the glass and the quantitative effects of the individual oxides was noticed, and the method of obtaining these factors was indicated. The variation of a physical property due to the increase of one particular oxide, the others remaining constant, could be indicated graphically, and in this case the curve was never linear. When the variation of physical property due to the replacement of one oxide by a second, weight for weight, was plotted, a curve was obtained which was named by Z. a "permutant." Examination of permutants given by several investigators was carried out. Some were linear, others curved, indicating in the latter case that the property in question was not a simple additive function of the oxides considered. When the function was approximately additive it was possible to calculate the physical

property in the case of a mixed glass from the values of two fundamental glasses from which it was obtained. It was suggested as a practical procedure that the properties of certain fundamental glasses should be determined and the variation of these properties with the variation of each individual oxide in successive regular amounts obtained, the results then being presented either in tabular or graphic form. (*Jour. Soc. Glass Tech. Abs.*)

BOOK

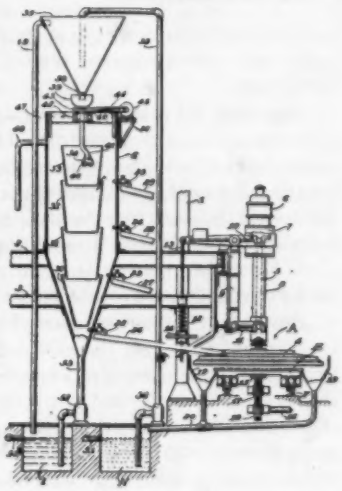
Surface brightness of diffusing glassware for illumination. C. W. J. GRIEVESON. Tech. Paper No. 4 of Dept. of Sci. & Ind. Res.: Illumination Research. London: H. M. Stationery Office. Price 9 pence. H.H.S.

PATENTS

Glass composition. W. C. TAYLOR. U. S. 1,615,247, Jan. 25, 1927. Process of making translucent glass comprising melting a batch substantially consisting of boric oxide, alkali, silica, and a salt containing a halogen whose atomic weight is over 34 and under 81.

Glass-melting tank. FREDERICK GELSTHARP. U. S. 1,615,832, Feb. 1, 1927. In combination in a glass tank having a melting end and a withdrawing end provided with an outlet from which the glass is withdrawn or fed under the head pressure of the tank, of a metal cooling pipe submerged in the glass at the withdrawing end, but spaced away from the outlet, and means for circulating a cooling fluid therethrough.

Glass-grinding process and apparatus. FREDERICK GELSTHARP AND J. C. PARKINSON. U. S. 1,615,833, Feb. 1, 1927. In combination with a grinding machine, a sump arranged to receive the mixture of used abrasive and water from the machine, a grading tank, a dewatering receptacle located above the tank and discharging into the top thereof, an overflow conduit leading from the upper portion of the receptacle, a second sump for receiving the overflow, means for continuously lifting the mixture of water and abrasive from the first sump and discharging it to the receptacle, means for supplying the water from the second sump upwardly to the lower portion of the grading tank to provide a grading flow upwardly therethrough, and means for withdrawing a mixture of water and abrasive of the required grade from the tank and supplying it to the grinding machine.



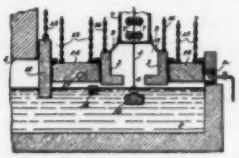
Apparatus for making plate glass. FREDERICK GELSTHARP. U. S. 1,615,834, Feb. 1, 1927. In combination, a glass tank containing a body of molten glass, and having a slot in its upper wall, a pair of horizontal driven and cooled sizing rolls seated in the slot, and having the lower portions of their peripheries immersed in the body of glass, and a glass receiving bed extending laterally from the side of one of the rolls for carrying away the glass which is formed.

Apparatus for making sheet glass. H. K. HITCHCOCK. U. S. 1,615,840, Feb. 1, 1927. The combination with a glass tank having an outlet slot, of an endless belt of flexible sheet material with its upper flight in position to receive the glass from the

slot, a roll over which the upper flight of the belt passes, and a sizing or dimensioning roll in opposition to the roll, the axes of the rolls being in the same plane lying at substantially a right angle to the line of travel of the glass.

Process and apparatus for drawing sheet glass. H. F. HITNER. U. S. 1,615,841, Feb. 1, 1927. The combination with a melting tank, of a transverse drawing kiln, a connecting neck between the adjacent sides of the melting tank and the kiln below the level of the glass, electrodes at the opposite ends of the kiln, means for causing a flow of electric current between the electrodes throughout the major portion of the cross-section of the kiln to heat the glass in the kiln, and means for drawing a sheet of glass upward from the kiln.

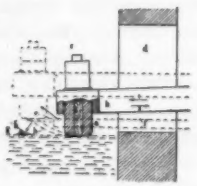
Apparatus for making sheet glass. H. F. HITNER. U. S. 1,615,842, Feb. 1, 1927. The combination with container for molten glass, of heating means therefor comprising a tube of refractory material extending through the body of glass, a resistance rod extending through the tube but out of contact therewith, and means for passing a current of electricity through the rod.



Sheet-glass-drawing apparatus. C. H. WRIGHT. U. S. 1,615,862, Feb. 1, 1927. The combination with a melting tank with a forehearth or drawing tank leading from one side thereof, of a pair of opposing blocks extending across the forehearth above the glass and spaced apart to provide a drawing opening, apparatus above the opening for drawing a sheet of glass continuously upward, and a top or roof plate to the rear of each of the blocks, also spaced above the surface of the glass, the one of such plates adjacent the outer end of the forehearth being mounted for vertical adjustment.

Apparatus for making sheet glass. C. H. WRIGHT. U. S. 1,615,863, Feb. 1, 1927. In combination with apparatus arranged to draw a glass sheet from an open pool of molten glass through a drawing chamber, of means in the chamber for preventing inward movement of the edge of the sheet, comprising a shielding plate spaced above the surface of the pool but closely adjacent thereto and having a slot extending inward from its edge and fitting around the edge of the sheet, and a cooling member comprising a box having an opening at its outer end and extending into the drawing chamber with its inner end positioned immediately above the plate.

Process of collecting glass by suction. ÉMILE ROIRANT. U. S. 1,615,886, Feb. 1, 1927. A process of collecting glass by suction by means of a suction mold which penetrates into the furnace, characterized by the fact that this mold, after having effected its suction, continues its movement toward the interior of the furnace; the blade effecting the cutting off at the end of this supplementary travel, so that the column cutoff falls back towards the side of the interior of the furnace.



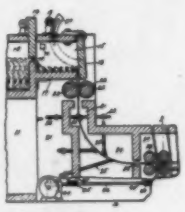
Glass-cutting machine. J. B. GREER. U. S. 1,615,978, Feb. 1, 1927. A glass-cutting machine comprising a chuck, cutting wheels arranged to move toward and away from the chuck, pivotally mounted supports for the cutting wheels, a spring connecting the supports and acting to move the cutting wheels toward the chuck, and independent connections between the cam and the supports for moving the cutting wheels away from the chuck, each of the connections comprising a bell crank lever arranged to be oscillated by the cam, and a link of adjustable length connecting the bell crank lever with its cutting wheel support.

Method of and apparatus for forming sheet glass. G. E. HOWARD. U. S. 1,616,370, Feb. 1, 1927. The method which comprises directing molten glass against an upwardly

moving surface, spreading the glass laterally on the surface, and causing the surface to carry the glass past a sheet-forming member.

Apparatus for forming sheet glass. G. E. HOWARD. U. S. 1,616,371, Feb. 1, 1927. Apparatus for forming sheet glass, which comprises means for drawing a sheet of glass from a molten bath, and means for engaging the sheet adjacent to its edges, comprising pairs of gripper arms which are movable laterally of the sheet, and which have movement independently of one another.

Machine and method for drawing glass. C. W. AVERY. U. S. 1,616,405, Feb. 1, 1927. In the art of producing a continuous glass sheet adapted to form the source of supply for the commercial product, the method of producing the sheet which consists in producing an embryo sheet formation from a constant source of supply of the molten glass, subjecting the embryo formation to a conditioning treatment while the formation is subject to complete and maximum gravity action exerted in the direction of sheet advance to give the sheet the desired dimensional characteristics, subjecting the conditioned sheet to a polishing action, and then leading the sheet laterally into the leer, the path of the sheet travel while subject to such gravity activity presenting the direction of sheet advance as including an initial vertical direction and a final horizontal direction, the intermediate portion of the flight having characteristics of an approximate arc of relatively large radius, the length of the radius being maintained approximately constant by the speed of advance of the sheet into the leer, the polishing activity being provided while the sheet is travelling within the curved portion of such flight.



Method of and apparatus for shaping molten glass. K. E. PEILER. U. S. 1,617,220, Feb. 8, 1927. The method of forming a parison which includes the steps of drawing a charge of molten glass from a mass into an imperforate mold cavity by a vacuum in the cavity, separating the charge from the mass, and applying pressure to the charge to force it upwardly into the cavity. Apparatus for shaping a glass parison, comprising a mold having an imperforate pocket, means for creating a partial vacuum within the pocket to suck the glass therein, and means for applying pressure to the glass in the mold to force it upwardly into contact with the wall of the pocket.

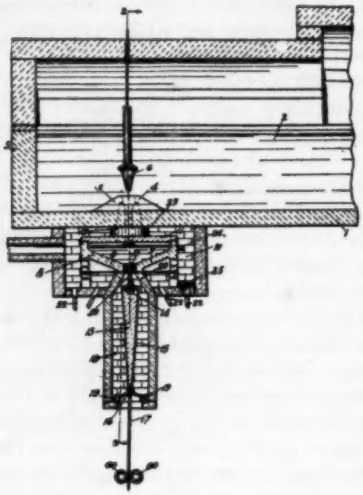
Method and apparatus for feeding molten glass. G. E. HOWARD. U. S. 1,617,598, Feb. 15, 1927. The method of feeding molten glass that comprises bringing the glass above a downwardly opening outlet, and forming freely-hanging gathers of glass below the outlet by alternate application of downward suction and upward pressure below the outlet.

Apparatus for forming glass sheets or plates. G. A. SHIELDS. U. S. 1,617,653, Feb. 15, 1927. In a device of the character described, a main tank, a working out chamber communicating with the tank, means for withdrawing glass from the chamber to form sheets, and an annealing chamber formed adjacent the main tank and adapted to be heated by radiation therefrom.

Production of sheet glass. NICKLAS FRANZEN. U. S. 1,617,800, Feb. 15, 1927. A grasping and conveying apparatus comprising a ways, a pipe slidable in the ways, a tong jaw fixed to the pipe at one end thereof, a second tong jaw pivoted to the pipe at the end through a bell crank and in operable relation with first the jaw to form a tong therewith, a rod extending through the pipe and movable therein and pivoted to second jaw through the bell crank, a collar on the rod at the end opposite the jaws at such a distance from the contiguous end of the pipe as to allow movement of the rod in the pipe to open and close the jaws on an object therebetween, and means connected with the end of the rod for opening and closing the jaws and moving the pipe on the ways.

Furnace for heating glass blanks. K. G. KUTCHKA. U. S. 1,617,955, Feb. 15, 1927. In combination, a furnace for heating blanks, comprising a tunnel chamber open at the

bottom, an endless carrier for blanks to be heated fitting into the bottom of the chamber and comprising a plate for supporting the blanks with a longitudinally extending supporting rib extending downward from the center of the plate, a longitudinally extending heating chamber on each side of the rib, gas heating means for the chambers, and means for moving the carrier forward to shift the blanks forward through the length of the tunnel chamber.



Drawing sheet glass. J. A. REECE. U. S. 1,617,107, Feb. 15, 1927. The method of making sheet glass, consisting in producing molten glass in a continuous tank furnace, flowing molten glass from the lower strata of glass in the tank into a separately enclosed pool, and flowing glass downwardly from the pool onto a slab from which it is drawn in sheet form.

Heat resisting glass. Brit. Pat., 242,568, Aug. 4, 1925; from *Illus. Official Jour. Pat.*, No. 1928, Dec. 31, 1925.—A glass which is insensitive to abrupt temperature changes contains at least 45% of silica, from 2 to 15% of boron trioxide, and from 4 to 30% of magnesia and lime together, and is characterized by the fact that it contains from 20 to 30% of alumina and not more than 8% of alkali oxide. The magnesia or lime may be replaced by barium oxide or zinc oxide in equivalent quantities, and lead oxide or antimony oxide may be introduced in quantities not exceeding 6%. Opal glass may be produced by the addition of substances usually used for this purpose. (*Jour. Soc. Glass Tech. Abs.*)

Glass for electric insulators. Brit. Pat., 245,131, Dec. 21, 1925; *Illus. Official Jour. Pat.*, No. 1935, Feb. 17, 1926.—In the production of a sodium-aluminium borosilicate glass, aluminium sulphate is used as a batch material in order to lower the melting point. A batch for making glass suitable for high voltage electric insulators consists of 81 parts of sand, 20 parts of crystallized aluminium sulphate, 28 parts of crystallized borax, and 2 parts of crystallized boric acid. (*Jour. Soc. Glass Tech. Abs.*)

Controlling the softening temperature of glass. W. C. SPROESSER. U. S. 1,565,598, Dec. 15, 1925.—The invention consists of a method of controlling the softening temperature of glass, a suggested use being to raise the softening temperature of the bulb of an X-ray or tube above that of the stems of cylindrical extensions. The method thus avoids the necessity of making such a tube of different kinds of glass. According to the invention, the glass to be treated is coated with a solution or suspension of a compound, and after the treated portion has dried, it is heated to cause a chemical combination or reaction between the applied material and the surface of the glass. The reaction results in the formation of a surface layer of glass which has a different softening temperature. Various salts, such as sodium tetraborate or boric oxide, have been found suitable for raising the softening temperature, but the best results have been obtained by using microcosmic salt (sodium ammonium hydrogen phosphate).

Heavy Clay Products

Standard specifications and tests for hollow fired-clay load-bearing wall tile. *A.S.T.M. Stands.*, 54–59 (1926), Ser. Desig., C 34–26.—Under these specifications are given 8 sections, giving detail requirements, as follows: classification, weights, dimen-

sions, weathering resistance, fire resistance, workmanship and finish, marking, inspection and rejection. In addition there are 4 sections giving methods of tests as follows: sampling, weight determinations, strength tests, absorption tests, and freezing tests. R.A.H.

Effect of a size of paving brick on rattler loss. F. H. JACKSON. *Proc. A.S.T.M.*, **26** [2], 602–10(1926).—Results are given of a series of tests made at the Bureau of Public Roads to determine the effect of size or volume of paving brick on the rattler loss. A series of 5 different sizes of brick from a single plant was tested in the rattler and a correction curve derived from the results obtained, which it is believed may be used in establishing a series of correction factors for use in specifications. R.A.H.

Determination of pressure distribution on circular pipe when tested in the A.S.T.M. standard sand bearings. D. G. MILLER AND P. C. MCGREW. *Proc. A.S.T.M.*, **26** [2], 611–20(1926).—Results of a series of tests are presented which show the distribution of pressure on both top and bottom quandrants of circular pipe when under load in the A.S.T.M. standard sand bearings as specified for testing sewer pipe and drain tile. It is recommended that when the standard method of test is used the sand contains about 5% moisture and that the sand of the lower bearing be loosened by spading immediately before placing tile for test. R.A.H.

On the winning of clays with a cable excavator. F. RIEDIG. *Keramos*, **5** [3], 135–36(1926).—A description of the use of a cable excavator to win clays which are on or close to the surface. E.J.V.

Official report of the fortieth annual convention of the National Brick Manufacturers' Association. ANON. *Clay-Worker*, **87** [2], 109–65(1927); *Brick Clay Rec.*, **70** [3], 198–202(1927).—The research committee of this Association suggested the following means of preventing drier scum: (1) dry wares as quickly as safety permits, (2) keep cold end of drier warm enough to prevent condensation, (3) set ware on drier cars in such a way as to obtain best drying conditions, (4) see that dampers between waste heat flues and firing kilns are properly closed, (5) clean all ashes from firebox of cooling kilns before drawing heat from them. Do not use heat until sulphur gases have escaped. A progress report of the N.B.M.A. drying investigation was made by R. K. Hursh. The laboratory phase of the investigation consisted in studying the following factors: (1) the effect of varying temperature, relative humidity, and rate of air movement on the rate of drying of typical brick clays and shales at different stages of drying; (2) relation of moisture loss to shrinkage and brick temperature; (3) study of water movement through the clay from the interior to the surface at different stages of drying and under different drying conditions. Charts are given showing the effect of these various factors. The temperature of the clay remains at the wet bulb temperature of the air during nearly the whole of the shrinkage period, then gradually rises to approach the dry bulb temperature. The rate of water loss remained practically constant during and for some time after the shrinkage period. A study of the operation and drying procedure in the progressive tunnel drier is being carried out at the plant of the Acme Brick Co. F.P.H.

Hidden and unexpected costs in the manufacture of clay wares. M. W. BLAIR. *Clay-Worker*, **87** [2], 132(1927). F.P.H.

Latest economics in quantity production in grinding clay. DAVIS BROWN. *Clay-Worker*, **87** [2], 139–40(1927). F.P.H.

Making sewer pipe on the west coast. ANON. *Brick Clay Rec.*, **70** [2], 116–18 (1927).—A description of the plant of the Pacific Clay Products Co. F.P.H.

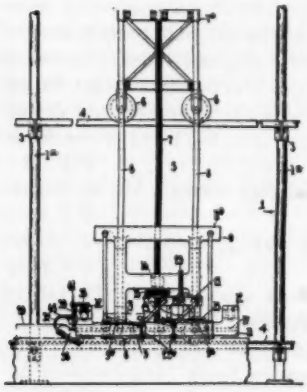
What you can see in Chicago plants. ANON. *Brick Clay Rec.*, **70** [3], 186–91 (1927). —Description of plants visited by delegates to the Common Brick Manufactures Association convention at Chicago. F.P.H.

Vitrified clay pipe. C. T. TROTTER. *Contract Rec. Eng. Rev.*, **40**, 31 (1926).—Clay pipe which has passed through the necessary manufacturing processes, has become vitrified and glazed, and is very like household china, with the same durability, sanitary quality, and the same facility for cleaning. Vitrified clay pipe, properly laid, will last indefinitely in the ground as it resists without deterioration the acids and gases invariably found in sewage. It occupies a much stronger position today, in the minds of experienced and practical engineers, than ever before. O.P.R.O.

Brick industry—Canada. O. O. OMUNDSON. *Contract Rec. Eng. Rev.*, **40**, 79 (1926).—There has been a gradual change from the use of clay to the use of shale for the manufacture of brick and other clay products. This increasing use of shale has developed the stiff-mud process of manufacture. More economical handling methods have been developed by the use of power shovels, electric and gasoline locomotives, self-dumping cars, narrow gage tracks, and mechanical feeders. Electric cranes have been introduced for mixing raw materials in storage. Grinders have been improved immensely and with more generously proportioned bucket elevators and vibrating screens of large dimensions grinding is entering upon a new era. Disk feeders and uoidometers keep a steady flow of material entering the pug mills and scum preventive agents added to the water insure face brick to have a clear color when fired. The variety of textures on face brick has called for special devices for obtaining these various sprfaces and one of the most recent accomplishments in auger machine operation is the development of the method of putting a jacket or surface of face brick material over a common clay body. This makes possible the production of a wide variety of colors with one material if the jacket composition is kept under control. Brick driers reflect progress in reduction of broken ware. Intelligent use of power recording and indicating devices, draft gages, thermometers, and pyrometers, has been a factor toward more positive control of production, bettering quality of bricks, and keeping costs down. O.P.R.O.

Silica-lime bricks. REMO DE FAZI. *Ann. chim. applicata*, **16**, 400–404 (1926).—Ostia sand gave an excellent product. The best composition was 85% sand and 15% CaO slaked with steam (at 8 atm.) during mixing, and heated 10 hrs. in autoclaves (at 8 atm.); this composition gave bricks with a resistance to compression of 200 kg. per sq. cm. The addition of hydraulic lime or of cement did not improve the quality. Maintaining the bricks at −5° for 40 days increased in most cases the resistance to compression and the moisture content. (*C. A.*)

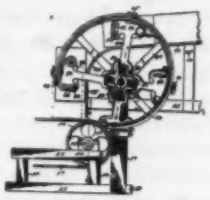
PATENTS



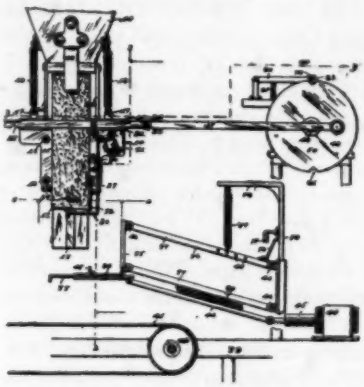
Apparatus for use in the laying of bricks and similar elements in building. G. E. WIGHT. U. S. 1,615,859, Feb. 1, 1927. In apparatus for laying bricks and the like in building, a carriage adapted to travel parallel with the face of the wall to be built, a tray on the carriage for reception of the bricks to be laid, a manually movable transfer device connected by links to the carriage for limited swinging movement from a picking up to a depositing position and vice versa, and manually operated means carried by the transfer device for gripping the bricks on the tray and releasing them at the depositing position.

Mechanism for transferring plastic blocks from one conveyer to another. H. R. STRAIGHT. U. S. 1,615,965, Feb. 1, 1927. In a device of the class described, a frame, a delivery chute, a receiving con-

veyer, means for successively transferring blocks from the delivery chute to the receiving conveyer from a substantially horizontal position to a substantially vertical position comprising a pair of spaced grippers, means for supporting and carrying the grippers in continuous rotary paths about a common center, means for simultaneously moving the grippers toward each other as they are being rotated, and means for moving the grippers simultaneously from each other at predetermined points of their movement, for the purposes stated.



Tile cutter. H. R. STRAIGHT. U. S. 1,615,966, Feb. 1, 1927. The combination of a tile machine arranged to deliver a continuously moving column of plastic material downwardly and in a vertical plane, means for severing the column into predetermined lengths as the column is being moved downwardly, means below the tile machine for receiving the severed sections, a second receiving means for delivering the severed sections to the first receiving means, the last said receiving means being adapted to travel downwardly at a speed higher than the speed of the column.



Refractories

The properties of refractories in the metallurgy of zinc. E. S. WHEELER AND A. H. KUECHLER. *Jour. Amer. Ceram. Soc.*, **10** [2], 109–131 (1927).—A study has been made of some of the properties of clays, grogs, and body mixtures used by various zinc smelters for the manufacture of zinc retorts. Only minor differences were observed in the properties of the clays. No attempt has been made to offer any of the results as conclusions. The investigation tends to confirm the following points: that the use of reclaimed retort material in the grog for new retorts is of doubtful economy; that, if old bricks or shapes are used as grog, care should be taken that they were originally made of good quality clay and that they are free from slag; that some flint clay of good quality and properly calcined is advisable for at least a part of the grog; and that zinc in a clay or body mixture markedly affects the refractoriness by lowering the deformation value.

Surface deposits in regenerators. HERBERT INSLEY. *Amer. Glass Rev.*, **46** [17], 15–16 (1927).—A microscopic study of highly aluminous brick, reported to contain 34.7% SiO_2 and 58.6% Al_2O_3, which were used in regenerators operated at 1100 to 1200°C, in one case and at 985 to 1100°C in the other. An examination of different portions of the brick used at 1100 to 1200°C shows the presence of corundum, mullite, and a little glass in the interior; mullite, a little glass, very little corundum; glass, corundum, a little mullite; glass, corundum in the border zone; and a surface deposit of nephelite ($Na_2O.Al_2O_3.2SiO_2$), and a little corundum. In the lower temperature service the brick showed a lesser development of mullite crystals in the interior, and the thin outer crust was composed principally of nephelite and carnegieite (the high temperature form of nephelite). The deposits formed on the surface were composed principally of nephelite and carnegieite, and corundum. The two forms of $Na_2O.Al_2O_3.2SiO_2$ probably form only in those parts of glass furnaces where the temperature is considerably lower than that required to melt the glass. E.J.V.

Laclede Christy Co. shows need for clay as an element in the world of industry. JOHN L. GREEN. *Nat. Glass Budget*, **42** [39], 15 (1927); reprinted from *St. Louis Globe Democrat*.—A discussion of clay as an indispensable element in the world of industry and the part taken in reaching this condition by the Laclede Christy Co. E.J.V.

See mullite blocks made in Vitrefrax factory. ANON. *Nat. Glass Budget*, **42** [42], 3 (1927).—The development of mullite block, raw materials used, treatment thereof to produce mullite, method of treating and forming the mullite into blocks, and firing them to 280°F are phases of the manufacture of "Durox" block explained to Southern California glass manufacturers who were also shown through the plant. E.J.V.

The Ceramic Society. ANON. *Pottery Gaz.*, **52** [596], 273–75 (1927).—"The Influence of Wet Grog on the Properties of Saggers and Other Refractories" by Z. Konarzewski, is a report of the study of the chief properties of fire bricks: contraction, specific gravity, porosity, tensile strength, crushing strength cold, and resistance to deformation at high temperatures, on 2 sets of grog fire bricks using wet grog in one and dry grog in the other. The tests were made on series of mixes containing 0, 10, 20, 40, and 60% grog. Results obtained show the bricks made with wet grog to have less contraction, 7.1 to 19.5% greater tensile strength, 4.9 to 14.9% greater cold crushing strength, greater porosity, and greater resistance to deformation over a wide range at high temperatures. The results merely indicate that of the 2 kinds of bricks made under similar conditions, those made with wet grog were better. Prof. Wheeler's paper "The Chemistry of Coal" was of a highly technical nature dealing with the chemistry of the coal substance itself. E.J.V.

Deformation behavior of the system anorthite-mullite-silica-magnetite. Bur. Stand. *Tech. News Bull.*, No. 117, pp. 3–4 (1927).—It appeared from a petrographic study of refractories slagged in service and cooled slowly that the above crystal phases predominated where the temperature had been sufficiently high to cause serious slagging difficulty. An investigation was undertaken to study the deformation behavior of various mixtures falling within the composition tetrahedron of which the above phases were the apices. Method of procedure of attacking this problem is given with some of the results obtained. R.A.H.

Bauxite in the United States. ANON. *Ceramic Age*, **9** [1], 6 (1927).—An abstract of a recent report of the Bureau of Mines giving the locations, appearances, names, and methods for determining the different varieties of bauxite. The value of bauxite can only be determined accurately by chemical analysis, although a rough test can be made with an agate mortar. A discussion of the markets, grades, and tariff on bauxite follows. A.E.R.W.

The Atom machine for testing refractories under load at high temperatures. ANON. *Engineering*, **123**, 67 (1927).—A machine exhibited at the Physical and Optical Societies Exhibition in London. A cylindrical specimen of the material to be tested is placed on an anvil of hard electrode C in a carbon-resistance furnace. A ram, also of electrode C, is placed on top of the specimen and loaded by weights suspended from a horizontal lever. As the temperature rises, the thermal expansion is indicated by a multiplying lever from the weight lever; and the softening point of the refractory is duly recorded on a clock-work drum. A curve connecting extension or contraction with time and with temperature is thus obtained, the upper carbon ram being provided with an axial hole through which readings from an optical pyrometer are taken. Curves exhibited with the machine showed very distinctly the abnormal expansion which occurs before the softening point of badly-fired silica brick is reached. H.H.S.

Should glass tank blocks be mullite or flux block? D. D. LILLEY. *Ceram. Ind.*, **8** [2], 166–70 (1927).—L. views the tank block problem from a cost standpoint. Calcu-

lations are made on the assumption that the mullite block lasts 3 times as long as flux block. On this basis the figures given show that the mullite block is the more economical to use. However it would be necessary to do something to increase the life of the furnace above the glass line to realize this condition. F. S. Thompson in discussing this article suggests that improved quality of the ware produced would favor the mullite block considerably. J. H. Gill states that the calculations should have been based on an 8-inch wall of mullite block instead of a 12-inch wall as Mr. Lilley used in his calculations. Thus the mullite block would be still more economical than the flux block. He also states that all parts of the furnace should be made of mullite. In discussing Mr. Lilley's article T. S. Curtis gives data and reasons for claims of superiority of Durox brick. F.P.H.

Society of Glass Technology studies tank block problems. ANON. *Ceram. Ind.*, **8** [2], 201 (1927).—The following papers are abstracted: (1) "Further Note on Sillimanite as a Glass Works Refractory," (2) "Some Corrosion and Erosion Phenomena and Their Bearing on the Macrostructure of Refractories," (3) "A Note on the X-ray Patterns of Mullite and Sillimanite," and (4) "Note on the Design of Parison Molds." F.P.H.

About mullite brick. ANON. *Brick Clay Rec.*, **70** [2], 114 (1927).—The sources and uses of mullite are described. The results of comparative tests made with mullite and clay block in a glass tank are shown. F.P.H.

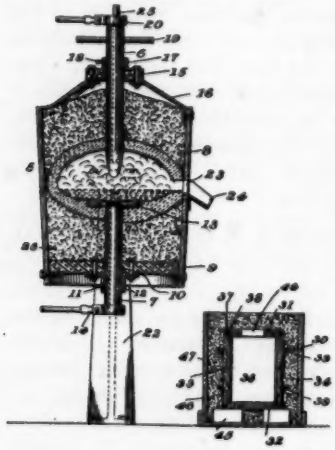
Diaspor and sillimanite as refractories. ANON. *Queensland Govt. Min. Jour.*, **27,** 387 (1926).—The use of bauxite for the production of highly refractory bricks and other articles has decreased markedly in recent years, according to R. J. Anderson, in *London Mining Jour.* Excessive shrinkage found in bauxite refractories does not take place in the diaspor refractories, and that development of these latter is one of the outstanding features of the ceramic industry in the last 25 years. Diaspor refractories, like the bauxite refractories, are for use in furnaces operating at high temperatures or in contact with basic slags. There is a continual widened use of diaspor refractories for special high-temperature conditions, and the cement industry is absorbing increasing tonnages for lining kilns. Another important development in the refractory field is the use of natural and artificial sillimanite. Valuable properties of this substance as a refractory are strength and toughness, high melting point (about 1810°C), low coefficient of expansion and electrical conductivity, freedom from volume changes, and neutral reaction. Artificial sillimanite may be made by melting together materials of the proper proportions of alumina and silica, or by melting clay and removing the excess silica, by carbon reduction. Artificial sillimanite has the formula $3Al_2O_3.2SiO_2$. Andalusite is being mined in California, the mineral being used in the manufacture of spark-plug porcelain. A large deposit of sillimanite has recently been discovered in India, about 100 miles from Calcutta, near a railway. The introduction of sillimanite into ceramic bodies greatly toughens and strengthens the bodies. Sillimanite bricks are recommended for construction of glass-works furnaces. O.P.R.O.

Sillimanite: Torrnes Gorge, South Australia. DOUGLAS MAWSON. *Trans. Roy. Soc. of S. A.*, **30,** 50 (1926).—A recent discovery of sillimanite was made in the vicinity of Adelaide. O.P.R.O.

Refractories for metals. Preliminary report of sub-committee on survey of the nonferrous foundry industry for the American Foundrymens' Association. H. M. ST. JOHN. *Metal Ind.*, (N. Y.) **24,** 450–3 (1926).—Furnace types are classified as follows: (*A*) using coke or hard coal, (1) crucible pit; (*B*) using soft coal, (2) crucible pit; (*C*) using oil or gas, (3) crucible pit, (4) crucible tilting, (5) open flame tilting, (6) open flame rotating, (7) reverberatory; (*D*) using electricity, (8) indirect resistance, (9) indirect

arc, rocking or rotating, (10) induction, (11) direct arc. Types 1, 3, 4, 5, 6, and 9 receive special attention. Thirteen conclusions relate to efficiencies, inadequate records, fluxes, patching, etc. (*C. A.*)

The production, properties, and experimental study of burnt magnesite. ALFRED STETTBACHER. *Chem.-Ztg.*, **50**, 741–42 (1926).—Calcined MgO, prepared from magnesite, may be used as the basis of millstones, grindstones, polishing stones and, in the case of the pure white variety, for chemical and ceramic products. It serves also as a base in the manufacture of stone-and-wood compositions for jointless flooring, walls, etc. Grecian (Euboean) and Silesian magnesite find favor in Europe and the Indian and Californian in the U. S. A crystalline variety found in Washington State is not much used commercially. S. asserts that the prejudice against the crystalline mineral is without foundation. The crushed mineral is fired in special ovens between 700 and 1100°, losing 48–51% by weight. The optimum temperature depends on the nature of the material and the type of apparatus and although the pure compound, $MgCO_3$, loses all its CO_2 at 510°, the mineral is only about 30% decomposed at 700°. Since, furthermore, an excess temperature over that actually required for decomposition serves later to retard the deterioration of the calcined product it is found necessary to heat to 900–1100°. Analyses of 4 typical calcined products are given and it is pointed out that high MgO content is not the only desideratum; the nature of the impurities is very important. Undecomposed $MgCO_3$ and considerable $Al_2O_3.Fe_2O_3$ are undesirable, but CaO is the most deleterious impurity of all because it subsequently produces "blows" in the cement products made from the calx. Some H_2O is always found but is invariably attributable to atmospheric action after calcination. The *n* rises with calcination and hence serves as an aid in deciding when the process is completed. The fineness of the product is second only in importance to the chemical composition since it is one of the determining factors in the rate and hardness of the setting. The common uses of the calcined MgO depend primarily on its capacity for reaction with $MgCl_2$ and H_2O to form a cementlike mass. Tests of the burnt MgO consist in determining (1) time of setting, (2) the tensile strength of the hard mass and (3) stability of volume after setting. The first is arrived at by reaction between the calx and $MgCl_2$ solution, the mixture being made into a porridge. Ratios given are 100 g. calx to 50–65 cc $MgCl_2$ solution 20° Bé or calx to equal weight of $MgCl_2$ solution 22° Bé. Tensile strength and stability of volume are both measured by means of so-called Bauschinger rods or bars prepared from calx, $MgCl_2$ solution, and pine sawdust. It is pointed out that the speed of hardening is almost independent of the chemical composition whereas for high tensile strength and great stability of volume of hard mass, the calcination must be carried to completion and at a high temperature. When the optimum temperature for a given material and apparatus has been determined, the chemical and essential physical properties of the calx can be predicted. Hence the chemist should devote his attention more to the oven and less to the finer details of the chemical analysis. (*C. A.*)



PATENTS

Cast refractory article and method of making

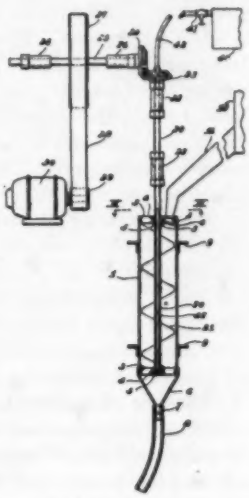
the same. G. S. FULCHER. U. S. 1,615,750, Jan. 25, 1927. An annealed refractory casting, composed of compact, indigenous crystalline material.

Cast refractory product. G. S. FULCHER. U. S. 1,615,751, Jan. 25, 1927. An annealed refractory casting analytically containing a compound of zirconium in substantial quantities, and consisting of indigenous crystals in a glassy matrix.

Magnesite refractory and method of making the same. AUGUST MARKS. U. S. 1,616,055, Feb. 1, 1927. The described method of making magnesite bricks or molded refractories, comprising mixing a pulverized magnesitic body material with linseed oil, molding, curing the molded article, and firing.

Unfired refractory brick and method of making it. AUGUST MARKS. U. S. 1,616,192, Feb. 1, 1927. An unburned magnesite brick or like refractory composed of a magnesitic body material which has been mixed with a suitable siccative oil, molded and dried to hardness.

Article of sillimanite-bonded granular material and method of making the same. M. C. BOOZE. U. S. 1,616,525, Feb. 8, 1927. A ceramic article comprising super-refractory grains in graded sizes serving as the chief refractory ingredient thereof which are united into an integral mass by a relatively small amount of bond located in the interstices between the grains, the major portion of which is a synthetic sillimanite of the formula $x\ Al_2O_3.\ y\ SiO_2$.



Silica brick gun. W. A. MILLER. U. S. 1,617,959, Feb. 15, 1927. Apparatus for discharging moist granular silica material, comprising a vertically arranged cylindrical container, a screw conveyer inside the container for feeding material therethrough, a conduit axially positioned relative to the container and adapted to supply gas under pressure at the discharge end of the container, the container having discharge openings positioned around the open end of the gas conduit, a conical shell surrounding the discharge end of the container, and a flexible hose leading from the conical shell whereby to discharge material from the container at various points without moving the container.

White Wares

A preliminary study of the resistance to abrasion of ceramic glazes, its control and methods of determination. A. C. HARRISON. *Jour. Amer. Ceram. Soc.*, **10** [2], 77–89 (1927).—Two test methods, one using an Ingersoll glarimeter to obtain results of a high degree of accuracy, and the other simpler "alternate method" for plant control, are described in detail. Tests on commercial hotel chinaware showed the average resistance of foreign ware was higher than that of the domestic and the variation from the average was, in general, less. Experimental glazes were prepared to study the effect on resistance, of: (1) varying SiO_2 and Al_2O_3 content, (2) glaze thickness, and (3) firing treatment. Data obtained are insufficient to justify definite conclusions regarding the effect of varying SiO_2 and Al_2O_3, but do show the resistance of well-matured glazes to be inversely proportional to thickness, a decrease in resistance as the tendency to matt increases, a markedly increased resistance by the higher glost fire. That type of body affects resistance less than do glaze composition and temperature of glost fire.

Impact and static transverse strength of wet process electrical porcelain. LOUIS NAVIAS. *Jour. Amer. Ceram. Soc.*, **10** [2], 90–97 (1927).—A brief review is given of the

apparatus used for determining the resistance to impact of ceramic materials, namely apparatus of the "pile driver" type and of the pendulum type. A Charpy (pendulum) transverse impact machine of 2 ft.-lbs. maximum capacity suitable for porcelain has been built and is described. Specimens from ½ to 1¼ inches in diameter can be accommodated on movable supports. Data were obtained for ½, ¾, 1, and 1¼ inch diameter cylinders of wet process porcelain on a 4-inch span, the average values for ½-inch diameter being 1.24 ft.-lbs. per sq. in., and the average value for ¾, 1, and 1¼ inches being 1.53 ft.-lbs. per sq. in. with an average deviation from the mean of about 2.5%. Data on specimens of wet process porcelain ½, ¾, 1, and 1¼ inch in diameter fractured on 4- and 5-inch spans give equivalent values for the modulus of rupture. The average of all values is 11,000 pounds per square inch.

Investigation of feldspar. ANON. Bur. Stand., *Tech. News Bull.*, No. 117, pp. 4–5 (1927).—The first phase of this investigation covering the study of the characteristic properties of 19 typical commercial feldspars is nearing completion. Composition of 3 feldspars is given. Fineness determinations made by the Bureau and 4 coöperating laboratories compared. The softening ranges of the feldspars varied almost directly as the K_2O content. Variations in true specific gravity noted. Tentative conclusions indicate that the variations in composition and fineness of grind do not have marked effect on translucency, porosity, and volume shrinkage of the whiteware bodies fired to various temperatures. Results indicate that these properties may have an appreciable effect on the mechanical strength. R.A.H.

Impact testing of insulating materials. W. W. WERRING. *Proc. A.S.T.M.*, **26** [2], 635–54 (1926).—A discussion of the impact test of the insulating materials and of the development of low capacity pendulum type machines of sufficient sensitivity for the purpose. Both Charpy and Izod type tests are discussed and comparative data shown. Results of static flexure tests of both plain and notched bars are given in comparison with similar impact test results. The effect of initial energy of impact and initial velocity of impact are shown by graphs. Five conclusions are drawn. R.A.H.

The use of water-glass in casting clay ware. ANON. *Pottery Gaz.*, **52** [596], 317 (1927).—Data obtained in an investigation of the effect of variation in compositions of sodium silicate or water-glass seem to justify the following conclusions: (1) sodium silicates low in soda and high in silica between the ratios of 1 : 33 to 1 : 4 are the most effective deflocculating agents for a given Na_2O content, (2) for the clays of this investigation minimum viscosity occurred when the slips were acid (p_H value less than 7), (3) silica sol (SiO_2) used alone is not a deflocculating agent. E.J.V.

Homer Laughlin China Company soon to build another pottery in Newell—will be a tunnel-kiln plant. ANON. *Pottery, Glass and Brass Salesman*, **34** [26], 27 (1927).—A note regarding the plans for "Factory No. 7," which is being considered as an addition to the present 6 plants of the Company. E.J.V.

240,000 spark plugs daily. ANON. *Ceram. Ind.*, **8** [2], 202–205 (1927).—A description of the plant of the Champion Porcelain Co. F.P.H.

How textile porcelain is made. ANON. *Ceram. Ind.*, **8** [2], 206 (1927).—A description of the plant of the Mitchell-Bissell Co. where porcelain guides for use on textile machinery, porcelain handles, knobs, escutcheons, and other porcelain parts are manufactured. F.P.H.

Characteristics of porcelain kaolin. G. GIANOLI. *Industria*, **40**, 271 (1926).—Zettlitz kaolin contains 95–99% of Al silicate, partly as kaolinite and partly in an amorphous or colloidal form, with very little quartz, feldspar, mica, other minerals and organic matter. It contains 45.66–47.83% SiO_2, 36.83–39.10% Al_2O_3, 0.43–1.01% Fe_2O_3, 0.36–0.50% TiO_2, 0.08–0.78% CaO, 0.10–0.38% MgO, 0.30–1% K_2O, 0.27–0.70% Na_2O. The loss in calcination is 12–14.10%. The density in the dry condition is 2.63, when warmed to 800° 2.53, 1000° 2.68, 1315° 2.67. Dried at 110° it regains

5.88% of H_2O if kept under a cover with 10% H_2SO_4. From 42% to 58.8% of H_2O is required for making a plastic mass, 65.3% for a liquid paste, or 47.2% with soda. The drying shrinkage varies between 4.2% and 5.2% with contents of H_2O between 42 and 53.8%. During firing dissociation begins at 575°, with absorption of 3 calories. The exothermic reaction starts at 950° with development of 0.5 calory. The firing shrinkage is 1.9% at 900°, 2.8% at 1000°, 6.5% at 1100°, 12.8% at 1300°, 13.8% at 1350°. The water absorption after firing reaches 31.9% with a temperature of 900°, 30.8% at 1000°, 22% at 1100°, 10.6% at 1300°, 6.5% at 1435°. The mechanical resistance in kg. per sq. cm. after drying at 110° is 2.5 (tension), 14 (compression), 2.7 (cross-breaking). (*C. A.*)

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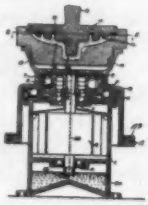

Method of and apparatus for making insulators. G. M. EATON. U. S. 1,615,800, Jan. 25, 1927. A device for working plastic bodies which comprises a base, a work table rotatably mounted thereon, means for rotating the table and centrifugal means for simultaneously vibrating the same.

Tile-fettling machine. A. W. CRISTIANI. U. S. 1,618,061, Feb. 15, 1927. A machine of the character described comprising a support to receive simultaneously a plurality of rows of objects, means for causing successively the objects of different ones of the rows to move on the support at different velocities and all of the objects to move at the same velocities whereby the objects of certain rows are caused to move ahead of the corresponding objects in the other rows, means for manipulating the objects on the support to position all of the objects in a single continuous row, and means for operating upon the objects as they are moved on the support.

Equipment and Apparatus

A laboratory apparatus for the refining of Pacific Northwest kaolin. ROLAND J. CLARK. *Jour. Amer. Ceram. Soc.*, **10** [2], 98–108 (1927).—A review of the clay purification methods which are used at the present time is given, together with a description of a simple laboratory continuous clay-washing plant composed of a screw feed, a rotary blunger, sand separator, cone-bowl classifier, and settling tanks. The methods of operation with a sample of Pacific Northwest kaolin and the results obtained are described.

A device for arc-welding easily oxidizable wires. HARRY P. COATS. *Jour. Amer. Chem. Soc.*, **48** [10], 2130–31 (1926).—A device very useful in welding thermocouples is described. R.J.P.

Rubber in the rock products industries. B. W. ROGERS. *Rock Products*, **30** [1], 37–40 (1927).—Particular reference is made to the qualities of rubber which make it an economic abrasion-protective-covering. The Vulcalock process which gives a good bond between rubber and metals such as steel, brass, aluminum, also wood and concrete is described. F.P.H.

Pneumatic conveying of gritty materials. E. J. TOURNIER. *Rock Products*, **30** [2], 40–50 (1927).—The general principles of pneumatic conveying are given and a description of the apparatus used is given. F.P.H.

The air separation of clay. W. B. PROUTY. *Brick Clay Rec.*, **70** [2], 112–13 (1927); *Ceram. Ind.*, **8** [2], 164–65 (1927).—A description of equipment used in the air separation of clay on a commercial scale. F.P.H.

Thermo-electric and resistance pyrometry in industry. J. A. HALL. *Chem. and Ind.*, **46**, 57 (1927).—The lack of coincidence of the resistance thermometer with the

thermodynamic scale is discussed, and the Callender correction is given. There are 3 methods of eliminating the resistance of leads: (*a*) the compensating lead method; (*b*) employment of 4 leads arranged in the form of current and potential leads, to each end of the thermometer bulb; (*c*) the method used for lower temperatures, in which copper leads are carried right up to the bulb of the thermometer. Methods *a* and *c* are of industrial importance. There is a big lag in recording instruments of this type, owing to the mechanical protection required for the resistance. Turning to thermocouples, H. prefers rare-metal couples, in spite of the lower e.m.f. and the fact that Pt is readily contaminated by other metals at high temperatures. The necessity of frequent calibration of pyrometers is emphasized. H.H.S.

New pyrometer. ANON. *Chem. and Ind.*, **46**, 96(1927).—The Cambridge Scientific Instrument Co. has produced a pyrometer for taking the temperatures of heated curved surfaces under working conditions. A reading is given in 3–5 seconds. H.H.S.

Modern forms of electrical temperature measuring devices. W. JAEKEL. *Die Messtechnik*, **2** [5–6], 56–59(1926); **2** [7], 95–98(1926); **2** [8], 127–28(1926).—The following types of temperature measuring devices are described as to make-up and principle involved in the operation thereof: (1) electric resistance thermometer, (2) thermoelectric pyrometer, (3) radiation pyrometer or ardometer, and (4) optical pyrometer. Various special forms of each of these types are also discussed. E.J.V.

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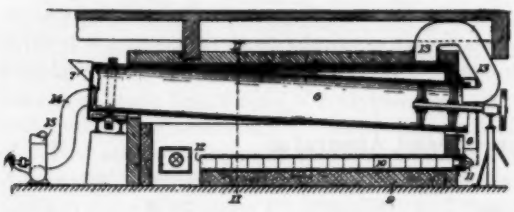

Drier. C. H. GREENWOOD. U. S. 1,615,222, Jan. 25, 1927. The combination with a horizontally arranged cylindrical rotary drier and a heating chamber within which the drier is mounted on an oil burner below the drier, a silicon carbide heating chamber extending forwardly under the drier from the fuel burner, the combustion chamber opening into the heating chamber, and a conduit leading from the heating chamber into one end of the shell of the drier.

Apparatus for elutriation or hydraulic classification of pigments, pottery slips, fullers' earth, abrasives, or other materials. L. ANDREWS. U. S. 1,610,725. Dec. 14, 1926. (*C. A.*)

Kilns, Furnaces, Fuels, and Combustion

Semi-automatic overhead transfers feature of new Mt. Clemens tunnel kiln. ANON. *Ceram. Ind.*, **8** [2], 205(1927).—A description of a tunnel kiln used at Mt. Clemens Pottery. F.P.H.

Fuel savings and kiln turnover. J. R. GROUT. *Clay-Worker*, **87** [2], 141–42(1927). F.P.H.

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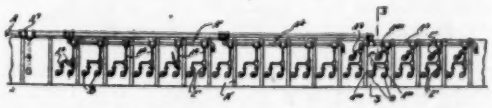
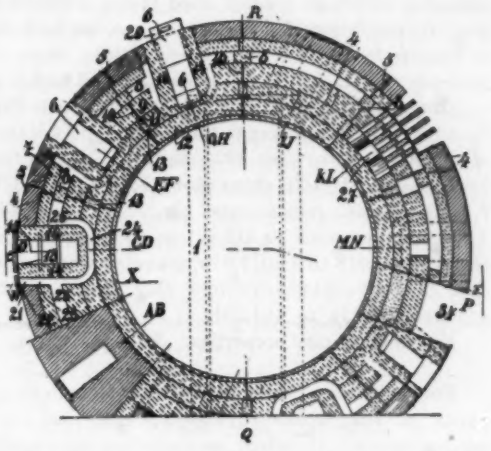
Tunnel-kiln-heating means. P. D'H. DRESSLER. U. S. 1,615,217, Jan. 25, 1927. In an open-fired tunnel kiln, a multiplicity of burners distributed longitudinally of the kiln, and fuel supply piping comprising a plurality of separately regulable branches to which the burners are connected in groups, each of which includes a plurality of burners connected to a single one of the branches and distributed along a

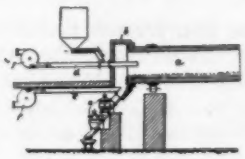


section of the kiln longitudinally displaced from the sections to which the other burner groups pertain.

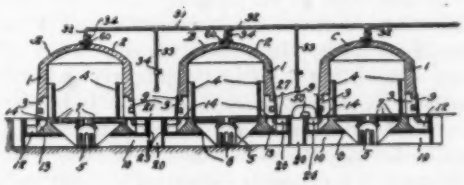
Vault for baking ovens or kilns. JULES LAURENT. U. S. 1,616,322, Feb. 1, 1927. A kiln comprising a circular-shaped brick work, a series of peripheral furnaces arranged about the brick work, the brick work being formed with passages to admit the heat of each of the furnaces to the interior of the circular-shaped brick work, and an air circulating passage for each furnace, the passage partly surrounding the furnace and extending into and forming a circular air cushion included within the circular brick work to provide an insulated layer of heated air about the circular brick work.



Rotary kiln for burning cement, magnesite, lime, and the like. HARRY STEHMANN. U. S. 1,617,137, Feb. 8, 1927. A rotary kiln for burning cement, magnesite, and lime, including a rotary inclined body portion, a head at the lower end thereof, an air-tight discharge device directly connected to the lower end of the head and means to admit fuel to the head and body portion, in combination with an air supply pipe arranged in the head to direct a current of air against the hot material discharging from the lower end of the kiln, the discharge device including 2 interconnected coöperating discharge valves spaced apart to prevent ingress of air during the discharge of the material.



Kiln. J. N. SILVA. U. S. 1,617,550, Feb. 15, 1927. The combination with a battery of kilns, of means for circulating the products of combustion through the kilns, and means for modifying the temperature of the products of combustion as they are being circulated.



Geology

Uses of fluorspar. ANON. *Ceramic Age*, **9** [1], 21 (1927).—An abstract of a recent report from the Bureau of Mines giving the mode of occurrence, physical and chemical properties, markets, and uses of fluorspar. A.E.R.W.

An interesting feldspar development. ANON. *Ceramic Age*, **9** [1], 28–29 (1927).—A description of the Tennessee Mineral Products Company, Spruce Pine, N. Car. A.E.R.W.

The Ceramic Society. ANON. *Pottery Gaz.*, **52** [595], 104–107 (1927).—The paper "Some Pottery China Clays and the Granite from which They are Derived," by J. M.

Coon, was read. C. assumes that china clay, as found in Devon and Cornwall is the result of a kaolinitic alteration of feldspar in a previously existing granite rock. The following subtopics are discussed in the paper: feldspars, natural impurities, disintegration, revelations by the microscope, granites compared, clays favored by potters, sillimanite formations, the mineral oxides, china clay standard analysis, and the importance of potash. A discussion followed and is given in brief. E.J.V.

Output of clay and other minerals in Great Britain. ANON. *Chem. and Ind.*, **46**, 12–13 (1927).—According to the annual report of the Mines Dept., the changes in output of minerals as between 1924 and 1925 are as follows: *Increase*: china clay 806,364 long tons to 850,160; china stone 54,703 to 57,379; felsite 35,908 to 36,127; calcspar 7,306 to 12,807; molding and pig-bed sand 648,840 to 679,559; fire clay 2,189,348 to 2,240,529; limestone 12,813,371 to 13,060,753; chalk 4,402,560 to 5,035,350; clay and shale 10,843,418 to 13,073,940; gravel and sand 2,922,485 to 3,741,961; *Decrease*: mica clay 23,633 to 20,834; potters' clay 225,951 to 206,826; fluorspar 49,492 to 39,079; ganister 634,431 to 494,293. H.H.S.

Valuation of clay properties. ELLIS LOVEJOY. *Clay-Worker*, **87** [2], 135–36 (1927). F.P.H.

Porcelain clay. Geol. and Min. Resources of Japan. Imperial Geol. Surv. of Japan, p. 104 (1926).—Argillaceous materials for the manufacture of porcelain and earthenware are abundant, as rocks bearing potash-feldspar, such as granite, porphyry and liparite, are widely distributed in Japan. O.P.R.O.

Chemistry and Physics

The equilibrium between zirconium oxide and carbon and their reaction products at incandescent temperatures. C. H. PRESCOTT, JR. *Jour. Amer. Chem. Soc.*, **48** [10], 2534–50 (1926).—An apparatus and technique for the study of chemical equilibria at incandescent temperatures are described. It is applied to the study of refractory oxides, in this case to the reaction between zirconium oxide and carbon. The reaction is shown to be $ZrO_2+3C=ZrC+2CO$. R.J.P.

The measurement of the permeability of ceramic bodies. P. W. KETCHUM, A. E. R. WESTMAN, AND R. K. HURSH. *Univ. Ill. Bull.*, **23** [50], 1–26 (1926), *Circ.*, No. 14, Eng. Exp. Station.—The permeability of a body is the property of permitting the passage of fluids. It is distinct from porosity, which has no direct connection with the flow of fluids but is rather the property of storing fluids. Permeability measurements enable very small changes in structure to be readily detected and, in combination with porosity measurements, afford a more precise description of the structure of a body than is afforded by porosity measurements alone. K., W., and H. give a brief description of the work of previous investigators and outline the general principles of permeameter design, with special reference to their use with ceramic bodies. They point out the convenience, and often necessity, of using air as the standard fluid and the necessity of securing equilibrium of flow, of using standard pressure differences and specimens of standard dimensions, and, in the case of unfired bodies, of accurately controlling moisture conditions. Permeameters of 2 types, called A and B, are described. Type A described by K., is used in measuring the permeability of small specimens of extremely small bodies; Type B, described by W. and H., is used with standard-sized fired refractories, or, with modifications, with full-sized unfired clay brick. For each type, the range of usefulness, construction, calibration, operation, and possible modifications to increase the range are given. In an appendix, the permeabilities of a number of ceramic materials which were measured are given. These include raw clay bodies, unfired face pick, face brick bfired to 800°C, plaster molds, and fired refractories. The use of rermeability measurements in investigations of thermal conductivity, resistance to slag,

spalling, drying behavior, and uniformity of texture is suggested, as well as the use of a Type A permeameter as a porosimeter. A.E.R.W.

Standard definitions of terms relating to the gypsum industry. *A.S.T.M. Stands.*, 60–61 (1926), Ser. Desig. C 11–26. Definitions of 12 terms adopted in 1926 are given. R.A.H.

Thermal expansion of clays and special refractories. ANON. Bur. Stand., *Tech. News Bull.*, No. 117, pp. 2–3 (1927).—Thermal expansion observations from room temperature to 1000°C have been made on foreign and domestic magnesite; diaspor, bauxite; Indian, Grecian, African, Turkish, and Cuban chrome ores; alumina, artificial corundum, cyanite, silicon carbide, zirconium silicate, 13 brands of fire brick from principal producing districts of the country; 3 brands of silica brick, and specimens of foreign and domestic ball clays. A comparison of the various types of materials is given and some discussion of the results. R.A.H.

Definitions of pyrometric terms. ANON. *Glass Indus.*, **8** [2], 31 (1927); reprinted from *Industrial Gas*.—Standardized definitions of the following terms are recommended for general use: thermometer, pyrometer, resistance thermometer, radiation pyrometer, optical pyrometer, thermocouple, thermoelectric pyrometer, hot junction, cold junction, extension leads, accuracy, and sensitivity. E.J.V.

Immiscibility in silicate melts. J. W. GREIG. *Amer. Jour. Sci.*, Pt. I, **13** [73], 1–44; Pt. II, **13** [74], 133–54 (1927).—It has been found that silica-rich mixtures of MgO, CaO, SrO, MnO, ZnO, FeO, NiO, or CoO, with SiO_2 melt to two immiscible liquids. No evidence of immiscibility has been found in the following binary system Al_2O_3–SiO_2, B_2O_3–SiO, K_2O–SiO_2, Na_2O–SiO_2. In ternary systems of silica with one of the former oxides and one of the latter there is but a narrow range of mixtures which give rise to 2 liquids on melting. In ternary systems of silica with 2 of the former oxides the range of composition of mixtures which melts to 2 liquids extends across the corner of the diagram. In those binary systems that show immiscibility the temperature of equilibrium between cristobalite and the 2 liquids is close to 1700°C and one of the liquids formed is nearly pure silica. In the system BaO–SiO_2 this immiscibility is not found but the form of the liquidus of cristobalite indicates the proximity of an area of immiscibility. As regards liquid miscibility with other oxides, silica is remarkably similar to boric oxide. All the oxides which this investigation has shown to be incompletely miscible with silica were found by Gertler to be incompletely miscible with boric oxide. The melting point of cristobalite has been redetermined and a value of 1713 ± 5°C obtained. The temperature of equilibrium between cristobalite and two liquids in the binary system CaO–SiO_2, 1698 ± 5°C is suggested as a suitable fixed thermometric point. The refractoriness of silica brick is decreased by alumina and the alkalis. The silica brick should be bonded with those oxides which are only partially miscible with silica. Clay is not such a bond; FeO, CaO, etc., are. The bearing on petrology is discussed. F.P.H.

Standardization in chemical analysis. W. H. ROBERTS. *Chem. and Ind.*, **46**, 58 (1927).—R. deprecates standardization as a fixed general principle, except in cases where something indefinite, such as in the Reichert-Wollny process for determination of butterfat, is to be measured. It is very difficult to get anybody to carry out a standard process literally; sooner or later a man will vary a process to suit himself, and even a slight difference may create great variations in the results. For standard processes there may be standard apparatus, and each apparatus must be very carefully calibrated. Preparation of the sample leads to variation; it is almost impossible to prepare a sample of about 14–15 lbs. which is uniform throughout. R. concludes that standardization is apt to make chemical thinking deteriorate, and that it is the duty of every analyst to work out his own processes. H.H.S.

A method of measuring the size of particles. P. LUBIRSKI AND M. KOSMAN. *Chem. and Ind.*, **46T**, 21–25 (1927).—An important paper by 2 Russian scientists on what may become a standard apparatus. Stokes's law on the velocity of spherical bodies falling through a liquid is: $v=2\ gr^2\ (\rho-d_0)/9\ \eta$, where r is the radius of the particle, ρ its density, d_0 the density of the liquid, and η its viscosity. Notwithstanding the fact that the particles have not a regular form, and do not strictly obey Stokes's law, the effective radius determined from the formula, as shown by experiments, fairly well characterizes the true dimensions of the particles. The apparatus consists of 3 tubes, one connecting with both the others. The first is filled with a suspension of the powder in the liquid, the others are filled with the pure liquid. As the particles fall, a difference in hydrostatic pressure is set up, causing a change in level in each of the auxiliary tubes. This is measured optically and the distribution of particles deduced. H.H.S.

The centrifugal method for the determination of the distribution of size of particle of suspended material. J. B. NICHOLS AND HENRIETTE C. LIEBE. *Third Colloid Symposium Monograph*, **1925**, 268–84.—Following mathematical discussion of the centrifugal method, there are given results of determinations of distribution of particle size for 6 lithopones, and their obscuring powers. The approximate relation between mass mean radius (radius dividing mass distribution curve into equal weights of material) and obscuring power, evidently depends on amount of surface oxidation as well as on size of particle. (*C. A.*)

On the testing of optical systems of Ronchi's interference methods. J. FLUGGE. *Z. Instr.*, **46**, 209 (1926).—A summary was given of a series of papers by V. Ronchi, published in various Italian journals, describing new methods of testing optical systems. These were interference methods in which a transmission grating was interposed in the path of the emergent beam at right angles to the optical axis. Interference bands were produced, and, by the use of a simple formula, the width of these bands was used to give a quantitative measurement of the aberation of the system under examination. A modification of the method enabled the focal length of an objective to be measured. Ronchi also applied the interference method to the determination of the resolving power of spectroscopic apparatus. The resolving power was related to the nature of the wave front emerging from the telescope object-glass of the spectroscope. If this wave was spherical, the resolving power was equal to $D/f\lambda$ where D/f was the aperture ratio of the object-glass. When this resolution was attained, the insertion into the path of the emergent beam of a grating having $D/2f\lambda$ lines per mm would produce a series of symmetrical interference bands. If, however, the bands were distorted, the test had to be repeated with gratings having wider rulings until a regular pattern was obtained. The width of the lines of the grating producing this effect gave a measure of the resolving power of the object-glass. (*Jour. Soc. Glass Tech. Abs.*)

An apparatus for the determination of the extinction coefficients of optical glasses for light in the visible spectrum. W. D. HAIGH. *Jour. Sci. Instr.*, **3**, 211 (1926).—The measuring apparatus consisted of a photo-electric cell connected to an electrometer in such a way that any variations in the photo-electric emission due to alterations in the intensity of the light entering the cell were recorded by the electrometer. A single beam of light was used. Two pairs of neutral wedges, mounted parallel to each other and at right angles to the direction of the beam, were adjusted so that the beam entering the cell was of the same intensity, whichever pair was in the path of the beam. The adjustment of one pair of wedges was then kept fixed. When the intensity of the light entering the cell through the fixed wedges was reduced by placing a slab of glass in the path of the beam, the needle of the electrometer was deflected. The second pair of wedges was then substituted for the glass block and the fixed wedges, and adjusted until a similar deflection was obtained on the electrometer. The absorption of the light in passing through the glass was calculated from the graduation factor of the

adjustable wedges and the distance through which one wedge had been moved across the other to balance the introduction of the glass. The extinction coefficient for the glass was obtained by making observations on two pieces of different lengths of the same glass for light of any particular wave-length. (*Jour. Soc. Glass Tech. Abs.*)

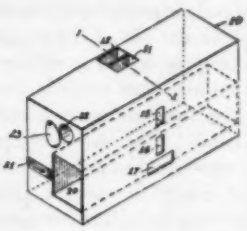
BOOKS

A Comprehensive Treatise on Inorganic and Theoretical Chemistry. Vol. VI Carbon (part II), Silicates. J. W. MELLOR. Longmans, Green and Co., 55 Fifth Ave., New York, 1925, x+1024 pp. 221 figs. 25 x 16 cms. Price 20 dollars. (Reviewed in *Jour. Amer. Chem. Soc.*, **48** [12], 3236(1926)).—A volume completing the chapters on carbon but devoting most of the volume to the chemistry of silicon and in particular to that of the silicates. A considerable part of the work is devoted to the chemistry of the silicate minerals. R.J.P.

Chemische Bodenanlyse. K. K. GEDROIZ. Trans. from Russ. by L. Frey. Pp. xii+245. Berlin: Gebrüder Borntraeger, 1926. Price 12 m. Soil analysis by a well-known authority. Reviewed in *Chem. and Ind.*, 110(1927). The reviewer regrets that there is no English translation. H.H.S.

PATENTS

Method and apparatus for determining hydrogen-ion concentration. E. D. STIRLEN. U. S. 1,616,092, Feb. 1, 1927. In an apparatus of the character described, the combination of a double wedge prism, 2 receptacles for holding a portion of a sample under investigation, means whereby one beam of light may be caused to pass through one receptacle and the prism, and means whereby a second beam of light may be caused to pass through the other of the receptacles containing another portion of the sample mixed with a known quantity of a chemical substance adapted to react with the sample, thereby producing in the first mentioned beam a color corresponding to a value which is being sought in the sample.



Process of manufacturing aluminum hydroxide. HARALD PEDERSEN. U. S. 1,618,105, Feb. 15, 1927. A process for producing aluminum hydroxide low in silica from slags and similar materials containing compounds of lime and alumina, comprising the step of leaching the material with a solution containing chiefly an alkali metal carbonate and containing also a small amount of free alkali metal hydroxide.

General

Federal and state support of experimental stations. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **6** [2], 45–47(1927).—Data regarding funds appropriated for the support of engineering experiment stations as contrasted with those for agricultural experiment stations are given. A plea for unification of the manufacturers to make possible coördinated efforts to increase the amounts for engineering is presented. E.J.V.

Ninety per cent of ceramic graduates are practicing ceramics. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **6** [2], 47(1927).—A review of the data showing the distribution of ceramic engineering graduates. E.J.V.

The value of a laboratory to a corporation. J. T. LITTLETON, JR. *Glass Indus.*, **8** [2], 40(1927); reprinted from *Corning Leader*.—Three types of activities which make a laboratory valuable to a corporation are: (A) production, (1) manufacturing control, (2) development of new processes; (B) sales, (1) determination by tests and measurements of the comparative value of the article, (2) development of new lines and new applications; (C) protection gained by the accumulation of accurate knowledge. These various phases are discussed in detail. E.J.V.

Ceramic chemistry. R. RIEKE. *Tonind. Ztg.*, **50** (50th Anniv. No.), 23–24 (1927). —In reviewing the progress made in ceramic chemistry during the past 50 years R. claims that a well equipped up-to-date ceramic laboratory would require much more and very expensive apparatus which was not known of 50 years ago. Colloidal chemistry has aided the ceramic industry in a better understanding of the casting process and also of the plasticity, bonding power, and drying properties of clays. It has also aided in the development of the electroösmotic method of purifying clays. Progress was made in the thermal analysis and petrographic examination of clays and these studies have shown that there are wide differences between clays. The decomposition of clays at the dehydration temperatures has been studied by means of thermal analysis and organic dye methods. These methods have also given us some idea of the changes taking place at higher temperatures. The Röntgen ray and the microscope also give valuable data at different firing temperatures. New methods of research have also thrown much light upon the transition of quartz at different temperatures. This has been a big help not only to the manufacture of silica brick but also in the firebrick, sagger, and whiteware industries. Different reactions take place in ceramic bodies involving chemical decomposition, transformations, melting, and solution processes as well as the formation of certain silicates which crystallize from soluble during cooling. Only when we thoroughly understand all of these reactions and their influence upon the quality of the ware can we produce products of the desired properties. Many of these problems can only be solved with the aid of other sciences closely allied to ceramics. Physical chemistry has, for example, aided in determining compounds and eutectics in mixtures. Much progress has also been made in the development of high temperature furnaces. Forty-five years ago Seger cones were about the only method employed for measuring temperatures of kilns. Now thermoelectric, optical, and radiation pyrometers are employed. Fifty years ago the only high temperature furnace used for determining the softening point of fire clays was the Deville furnace. Now we have air gas, electric resistance, and electric induction furnaces which go to higher temperatures and can be easier controlled. Together with the development of high temperature furnaces better refractories were also developed such as Al_2O_3, MgO, ZrO_2, and SiC. Substantial advance has also been made in the production of molten refractories as fused quartz. Much systematic work of great practical importance has been made by studying glazes with the aid of the molecular formula originated by Seger. The relation between the chemical composition of glazes and certain physical properties such as viscosity, coefficient of expansion, and elasticity have been investigated. Much progress has been made in determining the resistance of glazes to chemicals especially with Pb glazes. Studies have also been made of the solubility of various coloring oxides as well as noncoloring oxides of metals. Advance has also been made in crystal, aventurine, and matt glazes. Investigations have been made in blue and red Cu glazes, violet Mn glazes and many other colored glazes. A chemical resisting nonpoisoning Pb glaze has been developed. New uses have also been created for ceramic products. For example, electric light sockets, gas mantle supports, abrasives, insulators of steatite and steatite bodies, artificial teeth and other dental supplies, and laboratory apparatus. In 1913 the Tech. wissen. des Ver. keram. Gewerbe was organized and this was continued in 1919 as the Deut. Keram. Gesellschaft for the purpose of promoting and disseminating ceramic technology. H.G.S.

Can the hardness of materials be neglected in granulometric sieve analyses? H. P. HOLLNAGEL AND E. A. HARTY. *Proc. A.S.T.M.*, **26** [2], 655–59 (1926).—In making granulometric analyses of soft materials, like talc, the authors find that the mechanical action of sifting breaks up the materials and that the results are erratic. The length of time that the material is shaken, the kind of equipment and the methods employed should be standardized to permit duplication of results. Several graphs illustrating sieve analyses are given. R.A.H.

American Ceramic Society

1928 Annual Meeting

Ambassador Hotel, Atlantic City, N.J.

February 5-11, inclusive, 1928

The tentative program for meetings as agreed upon by the New Jersey Local Committee is as follows:

Sunday: Registration — President's Reception — Symphony Concert—Orchestra and Soloists—Dancing

Monday: 9:30 A.M. General Session
2:30-5:30 P.M. Division Meetings
8:30 P.M. Dinner Dance and Cabaret

Tuesday: 9:30 A.M.-12:30 P.M. Division Meetings
12:30-5:30 P.M. Division Meetings
8:30-10:00 P.M. Water Carnival

Wednesday: 9:30 A.M.-12:30 P.M. Division Meetings
2:30-5:30 P.M. General Meeting
7:30 P.M. Banquet

Thursday to Saturday, inclusive: Plant trips by Divisions in New Jersey, Pennsylvania, and Maryland.

LOCAL COMMITTEE, NEW JERSEY CLAY WORKERS ASSOCIATION

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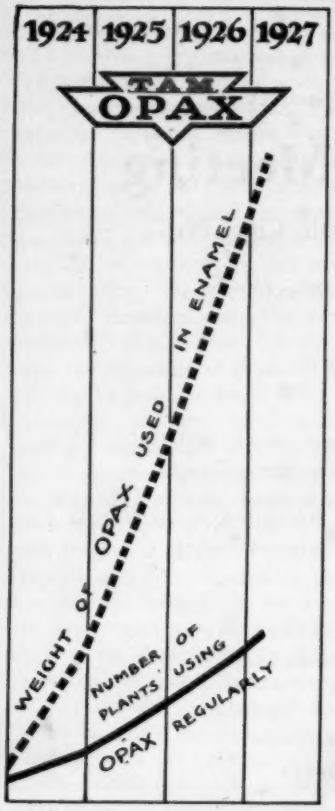

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BULLETIN

of the

AMERICAN CERAMIC SOCIETY

A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific and Art Questions and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

E. DEF. CURTIS, MARION FOSDICK, R. D. COOKE, H. G. WOLFRAM	Art, Enamel	H. L. DIXON, A. N. FINN, L. C. HEWITT, E. H. VAN SCHOICK, H. P. HUMPHREY, R. F. SHERWOOD	Glass, Refractories, White Wares	OSCAR MATHIASEN, J. R. BOWMAN, D. F. STEVENS, H. R. STRAIGHT	Terra Cotta, Heavy Clay Products

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Vol. 6 **April, 1927** **No. 4**

EDITORIAL

REPORT OF GENERAL SECRETARY, 1926-27

BY ROSS C. PURDY

Mr. President, Ladies, and Gentlemen, it is a pleasure to serve as the Secretary of this organization. The AMERICAN CERAMIC SOCIETY is closing the fifth year of service for a full-time secretary, and I wish to register with you my personal appreciation of the honor that our Board has rested on me as General Secretary during these five years.

As you know, I do not take my work seriously, although I am very much in earnest and am happy in my work. The success of the SOCIETY, however, is not due to the efforts of any one person or group of persons; it is due to the fact that we have a coöperative spirit, each of us endeavoring to serve our neighbor as we ourselves want to be served. Mutual organization is progressive only in that fashion.

Our seven Divisions are "officered" and "committeed" by men and women whose efforts are to provide the very best collection of information of interest to their particular group; *i. e.*, enamel information for the Enamel Division, etc. That is the real source of animation of this organization.

Those who are not, perchance, officers or members of a committee this particular year should feel it a duty to respond promptly to the request of the officers and committeemen, as you will want them in turn to respond when you are in office or are on a committee.

The President of the SOCIETY feels that his office is a great honor, as do the Treasurer and the other officers and trustees, but their work is light compared to the work of the Division officers.

These officers and committeemen take the lead in the work of the SOCIETY, but the work is not done by them; they are the correlating agencies. We are happy because, as an organization, we have as much real coöperation as is to be found in organizations of this sort. The fact that we can publish a *Journal* of the high character for which it is credited, that we can collect information of the high caliber for which it is generally recognized, with the size of membership we have, all at a low monetary cost, is a surprise to all who have had experience in such work. Several persons qualified by experience to testify have said that they could not understand how so much could be accomplished with the finances available. The secret of it lies in coördinated coöperation, exceptionally active. We are all working together, seven Divisions as a unit. That is the real secret of this organization, and if I have one plea that is more urgent than another, it is that you get behind those whom you will choose this year in your Divisions.

This SOCIETY, as the President has said, is engaged in two chief endeavors, collectively referred to as research and education. It is an unfortunate man who thinks that his education is completed; it is an unfortunate man who thinks he knows very much about the work in which he is engaged. It is indeed a very fortunate man who realizes that there is much for him yet to learn, that he can get a great deal from his neighbors, that the mite which he gives in the way of information to his neighbor, in exchange for that which he receives from the others associated with him is small, and that he can afford to be liberal in the giving of information.

This is education of the most virile sort. It is education of self.

We are, through our schools, engaged in educating those who are coming up without a very definite idea of what the future holds for them. They want to prepare for something. They have been advised to choose ceramics. Even then they do not know which branch they will choose. The purpose of our schools is to give them preparatory training, but after those boys are out of the school, and go into the shops and laboratories their education has just begun, as you know. But I want to testify as one who has been through the experience, that the education of those who are through school and are employed in manufacturing or in operating plants, is not much more completed than that of the boy who is just graduating from school. We ourselves lack a great deal of information needed in our work. The best that we can do is to struggle together to obtain the most information.

A manufacturer recently told me that practically everything he had in the way of fundamental information on which he is operating, was obtained through the agencies of this SOCIETY plus translation of that information by the college-bred men. That probably could be said by most of the manufacturers in the United States. All research is educational because it is simply a search for knowledge.

The report of our finances is already before you. The President referred to it in his address. The detailed figures are in the February number of the *Bulletin*.[1]

Our membership record is before you every month.

We have in this country about 10,000 persons who ought to be members of this SOCIETY, personal members. Where are the other 7700? You know them, they are waiting for your invitation. Imagine what this SOCIETY could do if all of these 10,000 persons were members of this organization.

We have in this country about five thousand corporations who ought to be supporting an organization of this sort as corporation members. You know them; they are waiting for your invitation.

I agree with the President[2] that we do not want any "sawdust-trail" enthusiasm, drumming up members; but I hope that his words will not be taken as meaning that you should in any way hesitate to invite those persons and those corporations whom you know ought to be supporting this organization.

We are particularly proud that our personal membership fee has not exceeded $10.00. Most organizations of this sort, doing equivalent work, have personal membership dues of $15, $20, or $25, and corporation membership dues of $50 or $100.

We have never had an assessment. In the years past, our financial reports have shown a loss. These losses have been due to the fact that we have written off of the books: (1) all members who are delinquent, and (2) most of our publications, so that the Financial Report shows only live assets. The SOCIETY has an invested interest of about $10,000, no outstanding obligations, in addition to about $10,000 on deposit; all of it is active material that could be turned into money quite readily. The old numbers of the *Journal* are being written off, most of our bibliographies are written off, as is the Collective Index for the *Transactions*. Not a delinquent is represented in the statement.

The time is coming when this organization will have a power financially to function, but that power is going to depend not upon money, but upon our will.

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[1] *Bull. Amer. Ceram. Soc.*, **6** [2], 54–56 (1927).

[2] See R. L. Clare, "Presidential Address," *Bull. Amer. Ceram. Soc.*, **6** [3], 67–69 (1927).

An hour ago a man in conversation said that he would pledge $1000 for each of the next five years, provided I could find ninety-nine other persons to make a like pledge, in support of any research which committees of this organization would care to undertake.

One of the ceramic trade organizations raised $50,000 for research almost on the instant that the plea was presented. The spirit is with us.

This SOCIETY is in no wise in competition with any of the trade organizations. The technical research which they undertake is being given support by this SOCIETY to the full extent of its ability. We desire that every trade organization should be engaged in research. It does not matter how secretly they hold the results of those investigations, or how they finance them, and what relations they might have with the conducting agency, such as a university or government bureau; as long as they are making investigations and are applying the results of those investigations, progress will be made.

In the same manner this SOCIETY is giving hearty support to the ceramic trade periodicals. These periodicals are broadcasting information. We should like to have this organization pack its covers to the maximum carrying capacity with boiled down facts, all good, sound data of general interest.

The ceramic press has changed from news into technical journals, and we are pleased. This SOCIETY, I am quite certain will, as time passes, have an increasing interest in the trade journals. These journals are all enthusiastically in support of the work which this organization is doing.

Now, the theme of my thoughts is that with all of the trade organizations, and with all of these journals, there is not one iota of competition, all simply going along the same path for the same purposes. There is need that these agencies keep in step with one another. Could there be a national organization common to all ceramic interests in which all could have a common interest, common support, and which would correlate the technical interests of these organizations in a way not to encroach on their private or individual interests? I am sure that an American Ceramic Research Council would serve as a unit force in more rapidly and at less expense increasing the total of ceramic knowledge, proved and applied.

You have heard the remarks of the President regarding the *Refractories Bibliography*.[3] Mr. Landrum and his associates have collected a bibliography on enameling literature which, with the abstracts, is equal in bulk to that of the *Refractories Bibliography*, and fully as complete, and is about ready for editing. Our small organization of one

[3] "Presidential Address," *loc. cit.*

man and three and one-half girls hopes to have this in your hands within a short while.

We also have a bibliography on white wares being compiled. Your committee on geology has one on feldspars, relating entirely to the geology and mineralogy of feldspars.

These bibliographies (collections of the literature as published) are the foundation of our education, because when a research or an investigation is to be undertaken the first thing to be done is to review that which has already been learned, so as not to duplicate, but to progress.

The enameling, white wares, and feldspar bibliographies will be out this year, without the least encroachment upon the budget which the Budget Committee is preparing.

PAPERS AND DISCUSSIONS

CONFERENCE ON CERAMIC RESEARCH

LED BY A. F. GREAVES-WALKER

A. F. GREAVES-WALKER: Although there is a great deal of research going on at the present time throughout the country, there is no coördination, and little coöperation, and there is a question of whether much of it is essential, unless it is directed properly toward the ends that would serve best.

With the view of getting some conclusions as to what we should best do, and in an effort to solve this problem that has been put before you, so that this SOCIETY can by some measure do what it should, we are calling for this discussion.

We all know that the British Government has been subsidizing ceramic research councils in Great Britain, and that because of these the British industries have advanced rapidly in comparison with what they did before the war.

The Canadian Government is also backing a Research Council.

Mr. Purdy will present this matter to us, because he has had the subject very close to his heart and for several years past he has brought it before us time and again in a brief way.

ROSS C. PURDY: The ceramic industries in Germany have organized a Ceramic Research Council within the past year, along exactly the same lines as has been proposed by this SOCIETY, and it is today functioning exactly as we have proposed. They caught the idea, and in their usual way have put it through. We are going to be at least one year behind them.

As to the research directly promoted by this SOCIETY, there seems to be wrong impressions existing. The Enamel Division Research Committee has met frequently during the year, has raised on its own solicitation among the enamel manufacturers a sum (I think it is $5000), and is carrying on quite an extensive investigation on both cast iron and sheet steel at the Bureau of Standards.

The Glass Division has an active Research Committee, with researches going on at different industrial plant laboratories and at the Bureau.

The heavy clay products industries, as a Division, are not active at present in coöperative research.

The Terra Cotta Research Committee, a few years ago, got under way with a very definite problem, and today, through the agency of the National Terra Cotta Association, is carrying on a very large investigation financed by the terra cotta manufacturers.

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[1] Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Detroit, Mich., Feb. 1927, (General Session.)

The white wares trade associations, through the several groups, such as the tile and dinner ware are advising and actually carrying on investigations at the Bureau and in some of the schools, suggestions for which originated in the White Wares Division.

The Refractories Division, through the American Refractories Institute and jointly with other organizations such as the Foundrymen's Association, is carrying on extensive investigations.

Two things which should be thoroughly understood are: (1) The German ceramic industries have already organized a Ceramic Research Council for and of themselves, and (2) that nearly all of the research committees of the Divisions of this SOCIETY are quite active.

It is proposed that we have an American Ceramic Research Council, which is not to finance investigations, which is not to handle money, and which is not to prosecute investigations, but one whose sole function would be to have available the information regarding (1) ceramic problems, and (2) the ceramic laboratories where investigations can be made, and to be able to advise each of the groups so that they can the most quickly prosecute the investigation they desire to make.

When an investigation is undertaken, the contact will be solely by the trade organization or industrial group which is to finance the work, with the laboratory that is to do the work. This advisory council would not be a factor in the prosecution of the investigations; it would have no control over the investigation, nor of the disposition of the results of the investigations; it would not in any way be involved in finances. It would, however, at all times serve in an advisory capacity to both parties.

For a beginning, we would need (1) to employ full time one or two men to study the ceramic problems of each group, and (2) to provide a cabinet of technical men from the industries who would meet periodically. This would give us the essentials of a virile advisory council. Such a modest beginning could be made on fifteen thousand dollars annual budget. On such an organization thirty or forty thousand dollars could be expended annually with assurance of profitable returns.

Understand, please, this idea would not set up a research organization whatsoever, but an advisory council only.

This SOCIETY, of its own volition and by political wire-pulling, has instituted ceramic divisions in the national bureaus. We then left them without support and they are now dependent upon the Director of the Bureau of Standards to obtain from Congress funds to carry on the research work. The present allotment to cover the ceramic work in the Bureau of Standards is about $125,000. (This may not be the exact figure.) This, the Bureau Director has obtained without any support whatsoever from the ceramic industries. It is his estimate of the amount

of money required. He made the request without full knowledge of the need for research on the part of the ceramic industries because the ceramic industries have made no effort to inform him.

The greatest amount of this sum was given to those groups which were most urgent, most persistent for investigations to be conducted.

The ceramic industries are not making an appeal to the Director, because they are not organized to make a concerted appeal. Some groups are making their wants known but ceramic industry as a unit is not. Therefore, the Director of the Bureau of Standards feels no particular urge to ask for money for ceramic investigation, except to use the organization which the Bureau has employed. The result is that the ceramic industries of this country are being served about one-tenth the amount that they should be served. The government should spend more money in fundamental research along ceramic lines (not that it should spend less on the other industries), but the ceramic industries deserve, and they could have their proportionate share, which is much larger than what they are getting of the money appropriated by Congress, providing they were organized to get it.

Monies are appropriated by the states for the support of universities. These instructional organizations desire to carry on research and they desire industrial contact. The need is there, but they do not know how to make that contact. The work now carried on by Prof. Greaves-Walker is an instance of what is possible. North Carolina State College was there before Prof. Greaves-Walker went there, ceramic raw materials were there, the market was there, but because he is a promoter for the ceramic interests within that State, they now have a ceramic department that is alive and growing, they are getting appropriations from the State, and getting attention from people outside of the State, focusing attention on that State. North Carolina, ceramically, is bound to go ahead in leaps and bounds because Prof. Greaves-Walker is there promoting this work. He came into a university that is keen to the situation. The men are still alive and young, as I understand it, who first introduced the idea of tax supported schools in North Carolina, so all of the school systems there are alert to the method of obtaining support from the Legislature.

In Ohio, the great grandchildren of those who labored for tax support of schools are now in the schools, but they have divorced their thoughts from the legislative needs. There is not that urge on the part of the schools in Ohio to solicit individual support of the industries, as there is in the Southern States.

Ohio was the first state to have a ceramic department, thirty-two years ago. It has had a state ceramic organization whenever there was

a need for concerted support of any project. At one time there were enough students in the ceramic department to graduate nineteen four-year men, plus about twenty men from the short course.

Notwithstanding all this leadership the ceramic department at Ohio State dwindled so that it finally had only fifty-eight students; not because it did not have a good faculty, good facilities, or because it did not want to serve the State, but simply because it had gotten out of touch with the industries.

Ohio has that contact today. There are two hundred students in the department. There is for the first time a ceramic department in the Engineering Experiment Station, and for the first time there is a full-time research professor partially paid by the industries and partially by the university. Other things are under way that are not essential to the point we are making this afternoon.

The point is this: Ohio ceramic industries have learned how to get behind their University, to get legislative support of the University to the extent of increased appropriations, increased research, and educational facilities. The State has now turned over the present State operated brick yards to the Experiment Station for the purposes of research. These brick yards are to be under the technical control of the research professor. There is to be a research laboratory in conjunction therewith. All of the kilns, the driers, and the manufacturing will be brought under the control supervision of the Ceramic Division of the Engineering Experiment Station. The product such as is made will be sold by the Welfare Board, and the state prisoners will be employed and directed by the Welfare Board. Ohio, in other words, is going to employ its State prison in the prosecution of research.

What is done in Ohio is what the other states can do and will do when they awaken to the facts.

Ceramics needs, in this country, a centralized activating force to show the industries how they may contact with the universities and to show the universities how they may contact with the industries, so that the large research facilities, already established, financed, and operated can be employed for the benefit of the ceramic industries.

The ceramic industries are paying their proportionate share of the cost of these Universities and they ought to be getting adequate returns. If it should cost the industries of this country twenty thousand dollars to know how to get their share they would find it to be a mighty large economy.

We already have in this country a National Research Council for the scientific needs. It is often asked why the AMERICAN CERAMIC SOCIETY does not become a part of that Council? That is possible, but not probable. It would be very hard indeed to get the ceramic

manufacturers to consent to become an integral part of that organization. They would feel that they were swallowed up. They would have to conform to rules and procedures that perhaps would not be altogether effective.

The National Research Council will aid us in organizing a Ceramic Research Council, but it would prefer that the ceramic industries organize their own council. The two would coöperate and collaborate in many ways.

It would be possible, through the influence of the National Research Council, to bring in outside financial assistance provided that we are organized to ask for that assistance. There are large endowments in this country that are idle, the interest on which is accumulating. The National Research Council is interesting those vast resources of finances. If an American Ceramic Research Council were organized it would collaborate with the National Research Council with the result that the ceramic industries would benefit from these endowments.

I have presented this idea several times, and lately the Board of Trustees, the Research Committee, and the officers of the Divisions were asked to vote as to its feasibility. The Board of Trustees voted unanimously in favor of presenting this matter and giving support to the idea in general. All but two members of the Research Committee approved it, and all but two of the officers of the Divisions approved it. There were five out of thirty-nine persons who withheld their support of this proposition.

This proposal was presented to the Terra Cotta Association; it was unanimously approved, and a resolution written which has already been published.[1] We now want to present it to the other associations, provided it is sound in principle.

R. D. LANDRUM: The greatest need is to secure some man whose job it is to know the problems of the industry, to know where those problems can be worked out, and to organize around him a sufficient number of men to make an active organization, and to accomplish the things that the SOCIETY has not been able to accomplish.

L. E. BARRINGER: I quite agree with the idea that research needs direction, and our particular field is perhaps even more complicated than other scientific fields. Just how to bring that about, though, I am not at all certain.

I endorse Mr. Landrum's suggestion that we ought to start. But I do not understand just what making the start involves. Does it involve financial support on the part of the AMERICAN CERAMIC SOCIETY? Does it involve tying in the universities and the Government

[1] *Bull. Amer. Ceram. Soc.*, **5** [1], 60 (1926).

laboratories? Does it involve a great deal of volunteer work, or is it mostly paid work?

Ross C. PURDY: The American Ceramic Research Council is not complicated. It is simple to have all of the ceramic interests in one organization. We were told when we wanted to have seven Divisions in this SOCIETY that such organization would be too complicated, but our industrial Divisions have worked successfully. We were told in Ohio that the attempt to organize the ceramic manufacturers was impossible, but many of those who doubted are now some of the best supporters of the Ohio Ceramic Industries Association. When we started, it was "hands off" until they saw we were going ahead.

The American Ceramic Research Council is more simple than the Ohio proposal. The proposition is that the several ceramic trade groups contribute to a common fund, possibly $15,000 a year to start with, to finance the full-time work of one man. That man would make a survey in each state, where ceramics is of economic importance, of the research facilities available. If he could do in other states what has been done voluntarily in Ohio, it would pay adequate returns on the money invested in this work.

The groups which finance jointly this full-time man would have an Executive Committee to correlate the needs of the associated groups. They would also set up an advisory cabinet with one representative from each of the trade groups.

How would the Institute respond to a request from a given group for counsel? For example, if the grinding wheel industry should wish to undertake an investigation, it could, as one of the supporters of the Council, lay its ideas before the chief adviser. He, with the grinding wheel representative on the advisory cabinet, would determine what is in the literature, what information, both fundamental and applied, is needed and where best the work can be done. The chances are that the preliminary survey would save much time and expense. Possibly the work could be subdivided and different portions done in laboratories best adapted because of equipment and personnel. The investigation might be carried on to the mutual advantage of the university and association at a very low cost, because these men have the survey of the problem and of the research facilities already available.

At the present time if a group of manufacturers wants a problem solved it goes to the Bureau of Standards (no criticism of the Bureau of Standards is intended) because it is assumed that the Government has the equipment, the personnel, and the intelligence necessary to solve any problem. Theoretically that ought to be so, but the group oftentimes presents the problem without adequate preliminary information of its own, the work is dribbled along because the Bureau has not

the time, facilities, and personal experience required for the best and most expeditious conducting of that study.

Mr. Clare, who has been active on the Research Committee of the National Terra Cotta Society, will agree that its problem has dragged along because there has not been a full-time disinterested activator on the job. The director now employed by the Government is being pulled on one side by the Bureau and the other side by the industry, and is not an impartial adviser.

The adviser whom we propose should not take an active part in investigations. It is reasonable that the work undertaken by the National Terra Cotta Society could be done at less cost by parcelling the investigations out to the laboratories best equipped for the work assigned, so that they would get much better work, in a shorter time.

If it is possible to have such an organization in Germany, it certainly is possible in this country. It is simply setting up a full-time research adviser to study the research facilities of industry, study the research problems, and to advise the trade associations.

A. F. GREAVES-WALKER: This SOCIETY will not be directly connected with the Council, but it would naturally be a member. The AMERICAN CERAMIC SOCIETY would not attempt to direct the research of all of these other organizations as some members have assumed. The SOCIETY is to sell this idea to the ceramic industries and get it started, then to let the financing organizations handle the proposition themselves.

B. M. HOOD: It seems to me that one of the biggest difficulties with this problem is to visualize how we can invest a dime and get back a dollar. If we can visualize that here, we can comprehend the idea.

We must feel that as an American nation we are in competition with other countries for foreign markets. We are spoiled in this country, having forty-eight countries with which we trade on the basis of free trade. There is no manufacturer that occupies as enviable a position as a leader in an industry in a country where he has forty-eight states in which he can enjoy free trade; but we have reached a period of economic surplus in this country, where we must look for foreign markets. We must have trained minds to produce materials that will compete in those foreign markets against lower labor costs, and lower standards of living.

We do not so much need a highly specialized research man at the head of the proposed Ceramic Research Council as an executive who would encourage research, avoid duplication, get a result quicker at lower cost, and eliminate waste. I do not know of anything that Secretary Hoover has done more effectively than standardization and the elimination of waste. If we can catch the idea of standardization

and put it over through a concentrated coördinated effort, we shall get ceramic results through research, ably directed, and we shall then accomplish definite results.

One of the handicaps of this movement is that it is rather generally thought that our Secretary is the "daddy" of the idea, and is the "daddy" of an idea to create a job for himself. This is plain speaking, but we have to brush away, sometimes, shades and shadows to arrive at the truth. I know your Secretary. He is not a candidate for the position. He is an enthusiast for the idea as the parent of a child. If there is some capable man who would come within the horizon to fill the position, the industry would naturally select that man. To get something done we need a method of transportation to carry the idea over, and that method of transportation is money.

I am not wedded to any scheme as to how the American Ceramic Research Council will be put over; but, as we mentioned before, the elimination of waste has been one of Mr. Hoover's finest accomplishments in the Department of Commerce in Washington. Waste and bankruptcies and failures are going on in this great, young, growing country, that can be turned into constructive channels in which industries can be more profitable, bigger dividends can be paid, greater sums put aside to the surplus, and our industries can grow, not alone nationally, but internationally successful.

T. B. ANDERSON: One reason that I approve of research work in ceramics is that I dislike to work. If there is any way to eliminate manual labor, I am in favor of it. We can easily recall the days when white ware was made practically by manual labor; that is being eliminated to a great extent, and the production cost lowered, which results in service to more people than ever before.

It is not often the man in the factory who brings forth the ideas that lessen the hard work connected with the industry. These ideas are brought forth by the idealists of the business, by men who use their imagination to project new ideas.

It is only a question of time until at least a large percentage of white ware will be fired in tunnel kilns because they reduce the amount of manual labor required.

In the older styles of firing ware, it is hardly expected that a kiln man will last longer than fifty-five years. He is generally ready to quit at fifty; but with the tunnel kiln, which removes a large percentage of the heavy labor, the kiln man's usefulness will be increased at least ten years.

I have always been in favor of research work, not because the pottery industry has been especially forward in it, but because other industries of much greater volume and greater extent and greater value to the

country have spent so much money, and time, and talent in the research work.

In our industry we very often find fellows who are worried about some little thing that has gone wrong in the plant; they would be glad if they knew where to turn for help. It really is true, as Mr. Hood has said, that much money has been wasted. Referring to the heavy clay products industry Mr. Hoover recently said that he had no doubt that there were at least five million dollars spent in needless building of plants for production of materials from clays that were not suitable for the purpose. I am glad to hear this borne out by Mr. Hood's remarks. In our immediate vicinity there are at least four plants in which enthusiastic men have spent large amounts of money that are idle today; and we all know that Ohio is a very large producer of heavy clay products.

So we should not give up the idea of the American Ceramic Research Council. There is not any question about its paying, and paying big.

MARION W. BLAIR: Five years ago, the AMERICAN CERAMIC SOCIETY volunteered to act as a clearing-house for information that would be derived from a coöperative ceramic research, and that research was put across, with the coöperation of four organizations, the American Face Brick Association, the National Paving Brick Association, the Common Brick, and the Building Tile Association. The results were published, but this information was never offered to the AMERICAN CERAMIC SOCIETY, and I shall venture to say that not 25% of the gentlemen in this room today ever saw the publication, and that 50% do not know that it exists; and yet this proposition was to be cleared through the AMERICAN CERAMIC SOCIETY. I refer to the investigation of industrial kilns. The results were criticized as being of no practical benefit, which positively is not true. I can take that publication and apply the results found there to any plant using periodic kilns and save from 15 to 25% of the kiln costs; but the industry as a whole did not recognize the application, and today it is almost impossible to get hold of a copy of the investigations. Only a few concerns in the industry as a whole received copies, and most of them did not even know how to read it.

A. F. GREAVES-WALKER: What Mr. Blair has said is true. The proposition that we have before us now would help to clear up that very situation. So far as we as a SOCIETY are concerned, it seems impossible to expect these Associations to make of this SOCIETY a clearing-house of the results of research work. That is entirely out of the question.

The idea we have is that each association shall select the problems, and choose the place of doing the work, and if it wishes to keep the

results of its investigations, which is paid out of its own pockets, under cover, or for the use of a few, that is entirely its own business.

The proposed Council would coördinate research, cut out waste, promote research along proper lines, and see that this work is done at the very lowest cost.

The objection that we have heard to this idea has been always that the AMERICAN CERAMIC SOCIETY could not act as a body in the matter, that it could not be an AMERICAN CERAMIC SOCIETY proposition. What we want to do is turn this idea over, sell it to the people who want to do research (I do not think there is the slightest question but what all of them want to do it), and see if we can get them together so that there will be less loss, less waste, and that there will be a definite organization promoting coöperative research in lines most essential to the ceramic industries.

J. B. SHAW: I venture a guess that 95% of the Program presented at this Meeting consists of papers that are the result of research investigations that have been carried on. The men who did this work and wrote these articles have been carrying on research in their various plants to the best of their ability. Does the Research Council propose to guide these men in this work to better advantage? Does the Research Council propose to go into these manufacturing plants where research is being carried out and assist them in raising funds for promoting such investigations, or does it propose to give these men information?

If it is the purpose of the director of this Council to give these men information which will enable them to carry out their investigations to better advantage, I doubt the ability of any single man in this country to do it. As Mr. Hood has said, we are living in an age of specialization, and I believe that the specialist is better able to carry out an investigation in his particular line than any man who may be selected by the ceramic industries.

The greatest need of the ceramic industries is research in the fundamentals. I am gratified to hear of the resolution that was passed by the Board of Trustees that the money which has been appropriated for the Bureau of Standards this year shall be spent in fundamental research. That is the greatest need of the ceramic industries today.

I am not in favor of the AMERICAN CERAMIC SOCIETY organizing a Research Council without some definite aim in view. I should like to see the proposers of this idea present a definite program and give us a definite idea of exactly what they propose to do, before we start out.

I believe it would be the better for such a Council not to go halfway, as proposed by Mr. Purdy, and act in an advisory capacity. I think that the AMERICAN CERAMIC SOCIETY should organize an institute and ask the various trade organizations to put up sufficient money to

support the institute which will study the fundamentals of ceramic reactions, and will carry out specific fundamental researches in ceramics. I believe they will have better success in securing such support than if they undertake the support of something indefinite and of doubtful value.

Instead of trying to raise $15,000 for an Advisory Committee, we should go to these people and try to raise $100,000, get a first-class scientist who is versed in the direction of research to direct the thing, secure sufficient laboratory equipment and sufficient personnel to establish a research laboratory of the AMERICAN CERAMIC SOCIETY which will be devoted to the fundamental problems in ceramics. That kind of research institute, I believe, would be of great benefit to the industries, and to the SOCIETY. Such an indefinite thing as has been proposed here, I am neither ready to oppose nor to support, because I do not know what it means.

R. J. MONTGOMERY: There is only one sound basis for tackling any problem and that is the direct method. If this Society is to assist in forming a Research Council it must sell the proposition to the trade associations. If this idea is sold to those associations, and they take it up as their own proposition and go ahead with it of their own volition, we shall get definite results. It is not necessary that it should be sold to all of them, but as in any marketing proposition, we must make a start some place.

The proposition could properly, perhaps, come from a scientific association, such as ours, but then it should be turned over to these men who are in position, and who psychologically are the only men who are going to get behind it and stay with it.

A. F. GREAVES-WALKER: For Prof. Shaw's benefit I am going to ask Mr. Purdy to again explain the idea that has been approved by the Board of Trustees of the SOCIETY.

R. C. PURDY: This is a matter which has been gone over carefully and thoroughly by the Board of Trustees, the officers of the Divisions, and the members of the Research Committee. Some correspondence has gone to a few of the schools, and I presume Professor Shaw has had some letters.

He wants something concrete. In Ohio we have a concrete illustration of getting the industries and the universities together. We have in this country vast investments in university research laboratories. They could be harnessed up for research to our benefit provided we could approach them intelligently.

A movement four years ago was started by the Refractories Division. It had samples fired at different kilns, and the petrographers at different laboratories were to make the investigations. The samples were pre-

pared and marked, and the work was carried up to the petrographers, with the result that the samples remained there. Why? Because there was not sufficient contact between those who started the program and those who were to make the observations. Those who were to make the observations did not feel they could spend the time merely to record what they saw. They wanted to correlate what they saw with the past history of the samples. That investigation lacked the carrying power that would be given by an organization such as we have in mind.

The proposed Research Council will never set up a laboratory of its own and will never handle finances. What Professor Shaw suggests is excellent, but quite different and much more remote in probabilities. What we propose is a small organization to sit in an advisory capacity to study the research facilities as to the best manner in which they can be employed.

Ohio's ceramic industries have for years been paying in support of the Ohio State University, and are just beginning now to get something back from their investment. Both the industries and the University are profiting. Both had to be shown how this could be done. What has been accomplished in Ohio can be done in other states.

Those who have studied the history of investments such as that kiln investigation which was done four years ago (that was never carried through to the plant application, simply because it lacked a directing force outside of the Bureau, outside of the schools, in the industries themselves) realize the potential profit that would accrue from an Advisory Council. If we can save from 10 to 50% in kiln firing on certain plants, why not do it in all plants in the country? That is what Mr. Hood is talking about. He wants a dollar's return from the ten cents he invested in that kiln study and such a profit is in that investigation provided the industries be led to make proper application of the facts disclosed.

If this Research Council did no other thing than to get the industries to apply the lessons learned in that one study, and to carry on the further fundamental investigations that are needed to complete that work, it would justify its existence.

We have in this country a National Research Council that has earned the support of the large corporations. Thirty million dollars are being raised today in support of that organization because such corporations as the American Telephone and Telegraph, with its three hundred research men and with millions already invested in research sees the value of having a National Research Council that will coördinate in research the various laboratories throughout the country. The organization of which Mr. Barringer is a member, the General Electric Company, is a heavy supporter of the National Research Council;

not because it is dissatisfied with the effort of its own Research Laboratories, but because it knows the value of coördinating the research laboratories of the country and the research efforts in the country.

The American Telephone and Telegraph Company, the General Electric Company, the Western Electric, the Westinghouse Electric, and many other big organizations, with big research organizations of their own, have increased their support of the National Research Council. Why? Because they feel that they will get more return from the work in which they are investing in their individual plants.

Now if it is true nationally and true generally scientifically, it is true in ceramics.

Let me give you another idea: If the Germans see this vision, what is wrong with us? Are ceramists in this country short-sighted?

A. F. GREAVES-WALKER: It is the desire of the Board of Trustees that the members of the SOCIETY assembled here shall vote on the question of this SOCIETY sponsoring the organization of an American Ceramic Research Council, merely getting an opinion expressed in a vote, as to whether they should proceed to work out this idea and to present it to the various industries.

The question was put to vote and as there was no opposition it appeared that the SOCIETY as a whole is in favor of the Board of Trustees proceeding in an effort to organize the proposed American Ceramic Research Council.

ACTIVITIES OF THE SOCIETY

DEFINITIONS OF WHITEWARES AND RELATED TERMS[1]

Progress Report to the White Wares Division

By Arthur S. Watts[2]

This Committee has grown in size by the inclusion of members of the Division who have indicated interest in the work until it now numbers nearly thirty and all other members interested are welcome to participate in this work.

Our efforts during the past year have resulted in a much clearer understanding of many ceramic terms and a list of several terms with proposed definitions are here appended, and will be submitted to ballot to the White Wares Division in the near future.

List of General Ceramic Terms

(Vote for one or if none suit, send your proposal to the Chairman)

(*a*) *Pore* (ceramic), An interstice or void in a body or glaze structure which is permeable by fluids.

(*b*) *Pore* (ceramic), A small opening, interstice or void between adjacent constituent particles. It may be open or sealed.

(*c*) *Pore* (ceramic), An interstitial space other than a crack or void due to external forces or to drying or firing strains.

(*a*) *Porous* (ceramic), Containing pores or voids which are permeable by fluids.

(*b*) *Porous* (ceramic), Containing pores or voids.

(*a*) *Porosity* (ceramic), The total volume of the pores expressed as a percentage of the exterior volume of the piece.

(*b*) *Porosity*, The quality or state of being porous.

(*a*) *Vitrify* (ceramic), To develop by heat such compactness of structure that the mass is impervious to fluids. *Note:* Commercial usage tolerates a limited penetration of fluids depending on service requirements.

(*b*) *Vitrify* (ceramic), To develop by heat such solution between constituents that the mass is impervious to fluids. *Note:* Same as (*a*).

(*c*) *Vitrify* (ceramic), To develop by heat such amount of glassy or liquid phase that a fracture surface has a glassy or a flintlike appearance and the mass is impervious to fluids. *Note:* Same as (*a*).

(*a*) *Vitreous* (ceramic), Nonabsorbent as a result of heat treatment.

(*b*) *Vitreous* (ceramic), Impervious to fluids, vitrified.

(*a*) *Semivitreous* (ceramic), Not completely vitrified.

(*a*) *Incipient Vitrification* (ceramic), That state produced by heat, in which contraction of the individual particles has reached a maximum and the first traces of solution between the constituents are visible by the aid of a microscope.

(*b*) *Incipient Vitrification* (ceramic), That state in which the first traces of fusion between constituents are visible.

(*a*) *Maturing Temperature* (ceramic), That temperature at which desired physical and chemical characteristics are attained.

(*b*) *Maturing Temperature* (ceramic), That temperature at which the article attains the physical and chemical characteristics required in wares of its class.

(*a*) *Porcelain*, White or nearly white ceramic ware translucent in thin sections and having vitreous structure.

(*b*) *Porcelain*, A vitreous ceramic ware, which is translucent in thin sections.

(*c*) *Porcelain*, A vitrified, white or tinted, ceramic ware which is translucent in thin sections.

(*d*) *Porcelain*, A vitrified ceramic product obtained by heating a properly blended

[1] Received March 2, 1927.

[2] Chairman, Standards Committee, White Wares Division.

mixture of siliceous materials with or without the addition of fluxes and characterized by a vitreous fracture, translucency in relatively thin sections and freedom from pores.

(*e*) *Porcelain*, The generic term employed to designate all kinds of pottery to which an incipient vitrification has been imparted by firing.

(*f*) *Porcelain*, A ceramic ware possessing to a prominent degree the properties of whiteness, translucency, imperviousness, hardness, and high fusibility. The more it excels in these respects, the better its quality.

(*g*) *Porcelain*, A ceramic body which in moderately thin layers is translucent. (Dr. Mellor).

(*h*) *Porcelain*, A translucent ceramic body with vitreous or glassy fracture.

(*i*) *Porcelain*, A vitreous ceramic product translucent in thin sections and containing microscopically visible mullite crystals.

(*a*) *Earthenware*, A porous, ceramic ware, devoid of translucency.

(*a*) *Whiteware*, A white porcelain, china or earthenware.

(*a*) *Semiporcelain* (indefinite). Same as white earthenware.

Porcelain vs. China

A very thorough survey of these two terms as used in both Europe and America indicates that unless they can be separated on the basis of composition or on characteristics of the finished product, the differentiation will not meet with general approval and adoption will be difficult if not impossible. Throughout continental Europe the term "porcelain" is used in referring to all vitreous ceramic bodies which display translucency to any appreciable degree. In referring to Chinese and Japanese ware the same term is used. In England and America the term is used only in referring to chemical and industrial ware.

The term "china" is used in both England and America in referring to all other vitreous ware which display translucency to an appreciable degree, including table or service ware and vitreous sanitary ware.

The term "porcelain" is erroneously used in America in referring to a semivitreous white ware which was formerly called semiporcelain but has been shortened by omitting the prefix.

A study of the vitreous ware classed as "porcelain" discloses the fact that they are either unglazed or covered with a "hard glaze," composed essentially of feldspar, alkaline earths, alumina, and silica, which matures at the same temperature as the body.

The term "china" generally refers to vitreous ware which is covered with a complex "soft glaze" containing boric acid and lead oxide or other bases which cause the glaze to mature at a temperature distinctly below the maturing temperature of the body and necessitating a preliminary hard fire for maturing the body followed by glaze application and maturing of the glaze at a separate low or moderate temperature.

The only serious exception to the foregoing classification is a growing habit in America, of referring to all vitreous translucent table ware as "china" *e. g.*, French china, Bavarian china, Austrian china.

On the basis of characteristic body and glaze, it would be highly desirable from a ceramic viewpoint to classify as follows:

Porcelain—China Differentiation

"Porcelain," all vitreous ware which is translucent in thin sections and unglazed or coated with a hard or difficultly fusible glaze maturing at the maturing temperature of the body.

"China," all vitreous ware which is translucent in thin sections and coated with a soft or moderately fusible glaze maturing at a distinctly lower temperature than the body.

On the basis of general usage, it can probably be claimed that the terms "porcelain" and "china" are synonymous, since the word "china" is not used in continental Europe, and the word "porcelain" is used in only an indefinite way in England and America.

If these terms are accepted as interchangeable, we should develop a classification by which the various types of porcelain or china may be differentiated beyond the common characteristics of vitrification and translucency in thin sections.

Fortunately such a classification is already in existence and with slight modifications could be adapted to general use.

Porcelain—China Classification

"High fire" or "hard porcelain," in which feldspar is the chief vitrifying agent, the other essential constituents being clay and flint.

"Low Fire" or "Soft Porcelains," in which the feldspar is materially supplemented by other vitrifying agents or the flint is increased at the expense of the clay or both, thereby lowering the temperature necessary for vitrification.

"Artificial Porcelains," in which either feldspar or flint is replaced by some other material.

High Fire or Hard Porcelains would naturally include:

(1) Industrial porcelains in which translucency and color are sacrificed for mechanical and electrical properties.

(2) Chemical porcelains, in which all other properties are sacrificed for chemical and temperature-change resistivity.

(3) Service porcelains, in which translucency, color, and mechanical strength are balanced, would be in this class, provided their compositions entitle them to be included.

(4) Art porcelains, in which color and translucency are developed at the expense of all other properties, may if their compositions justify, be included in this class.

Low Fire or Soft Porcelains would include;

(1) Seger porcelain which contains auxiliary vitrifying agents in addition to the feldspar and also abnormal flint content at the expense of clay.

(2) American china in which the feldspar is reduced and in part replaced by other vitrifying agents and the flint increased at the expense of the clay content.

NOTE: The peculiar and valuable qualities of this ware are due to their compositions and the fact that they mature at lower temperatures than the high fire porcelain does not indicate inferiority.

Artificial porcelains would include;

(1) Bone china in which the flint is partly or entirely replaced by calcined bone.

(2) Jasper or Wedgwood china in which the flint is replaced by barite (heavy feldspar).

(3) Belleek china in which the feldspar is replaced by a glass composed of feldspar and other vitrifying agents fused together and pulverized prior to incorporation in the body.

(4) French paste (Pâte Tendre) which was produced from a mixture of lime-soda glass, a calcareous clay, and quartz sand.

(5) American industrial porcelains in which the feldspar is replaced by an artificial vitrifying agent or the flint is replaced by an artificial nonplastic or both.

Such a porcelain-china classification may not meet the demands of those who claim that definitions must be based on properties of the product and who probably believe that classification should be on the same basis. It is doubtful however if any agreement could be reached for a classification on the basis of translucency or of mechanical properties and with the terms "porcelain" and "china" accepted as synonymous, the use of a classification would be confined to technical literature where a classification based on composition is as legitimate as in the field of metal alloys or glass.

It is hoped that the readers will give this presentation careful consideration and be prepared to vote and offer constructive criticisms when the ballot is received.

PERMISSIBLE MOISTURE CONTENT IN BALL CLAY[1]

The following is the Report of the Special Committee Appointed to Investigate Permissible Moisture Content in Ball Clay Shipments.

After a study of moisture content of ball clay shipments, including light, medium, and dark ball clays of both England and the United States, and including laboratory tests, reports from buyers and reports from shippers, the Committee finds:

(1) That the American shipper objects to any recommendation by this Committee of a maximum moisture content which the buyer can be reasonably expected to pay for.

(2) English ball clay shippers and agents agree that 20% moisture is a fair average of their shipments.

(3) Both American and English shippers urge that if shipments are to contain much less than 20% moisture, the clay must be handled during the summer months.

(4) All shippers claim that any attempt to dry the clay by artificial heat would add more to the market price than the saving in freight.

(5) Many shippers urge that a classification on the basis of color would not be satisfactory.

(6) The buyers of ball clay feel that many shippers are making no effort to protect the clay from an accumulation of moisture during handling and storage, and that the cost per ton of the clay delivered is thereby greatly increased.

(7) The buyers further claim that with reasonable care in handling and with protection from weather during storage the shipments need not contain more than 21% maximum moisture in the dark ball clays, 19% maximum moisture in mixed and medium ball clays, and 17% maximum moisture in light ball clays.

(8) The majority of buyers have suggested 20% maximum for dark, 18% for medium, and 16% maximum moisture content for light ball clay shipments.

(9) Most buyers recognize the undesirability of artificial heat driers for ball clays, but believe that reasonable protection of the mined clay will enable the shipper to deliver the clay with a moisture content below the maximum indicated above.

(10) Both shippers and buyers recognize that any control of the maximum moisture content in ball clay shipments must be accomplished by purchase specifications, which are subject only to such limitations as are definitely stated in writing and made a part of the contract between the parties concerned.

Respectfully submitted,
ARTHUR S. WATTS, *Chairman*

Report Approved: A. V. Bleininger, Geo. Brian, Geo. Simcoe, J. D. Whitmer, Paul Teetor. Approving items 1, 4, 5 and 10 only, R. W. Greene.

ELECTROMETRIC DETERMINATION OF IRON[1]

REFERENCES: J. C. Hostetter and H. S. Roberts, *Jour. Amer. Chem. Soc.*, **41**, 1337 (1920); and H. S. Roberts, *Jour. Amer. Chem. Soc.*, **41**, 1358 (1920).

To determine the oxidation-reduction potential of a given solution, it is sufficient to determine the potential difference between a platinum electrode and a standard electrode, the standard electrode usually being a calomel electrode connected to the solution by means of a salt bridge.

In the titration of a solution in oxidimetry the shift in potential resulting from a given addition of the titrating reagent depends not on the actual amount of the reagent added, but on the percentage alteration in the quantity of the material governing the potential of the solution. Hence, as the end point is approached small additions of the

[1] Arthur S. Watts, Chairman, Special Committee, White Wares Division.

[1] Adopted as Tentative Standard, Glass Division, AMERICAN CERAMIC SOCIETY, Feb., 1927.

titrating solution will produce increasingly great changes in potential, and after the end point is passed decreasingly great changes in potential. The maximum change occurs at the end point.

If the potentials be plotted against volume of the titrating solution we have a curve with a point of inflection at the end point of the reaction.

In the determination of iron by titration with potassium dichromate in hydrochloric acid subsequent to reduction with an excess of stannous chloride in hydrochloric acid, we have the following reactions:

$$2\ SnCl_2 + K_2Cr_2O_7 + 14\ HCl = 2\ CrCl_3 + 3\ SnCl_4 + 2\ KCl + H_2O$$

$$6\ FeCl_2 + K_2Cr_2O_7 + 14\ HCl = 2\ CrCl_3 + 6\ FeCl_3 + 2\ KCl + 7\ H_2O$$

The first reaction is completed before the second begins owing to the lower potential of stannous chloride. Hence we have two end points, or two points of inflection in the curve of potential against volume of potassium bichromate solution.

The second reaction is the one we desire to measure. It is the one taking place between the two end points. Hence our titration is the volume of solution added between the two end points.

The oxygen of the air will also effect the oxidation of both the stannous chloride and ferrous chloride. By using a narrow-mouthed flask this oxidation is so slow that by rapid work no appreciable error results. For extreme accuracy a flow of carbon dioxide should be maintained for at least five minutes before the titration and continued during the titration.

Apparatus and Standard Solution For the electrometric titration of iron in glass or glass-making materials the most convenient strength of potassium dichromate is 0.005 *N*. Of this solution 1.00 cc = 0.000399 g. iron oxide. To make up this solution dissolve 4.9 g. of C. P. potassium dichromate in 100 cc hot distilled water and dilute to 20 liters. Shake well.

Standardize this solution by titrating electrometrically in the usual manner accurately weighed samples of C. P. iron wire newly polished with emery cloth.

Factor on Solution

$$\frac{\text{g. FeO wire} \times 79.84}{\text{cc } K_2Cr_2O_7 \times 55.84} = \text{g. } Fe_2O_3/\text{cc}$$

Stannous Chloride Solution Dissolve 113 g. stannous chloride in 200 cc concentrated hydrochloric acid. Dilute to one liter and keep a few pieces of tin metal in contact with the solution.

Brine Solution for Salt Bridge Make a saturated solution of sodium chloride and arrange the customary glass siphon with about twelve inches of rubber tubing to connect with the half cell. A spring pinch clamp conserves the brine satisfactorily. Two liters of the brine should last several months.

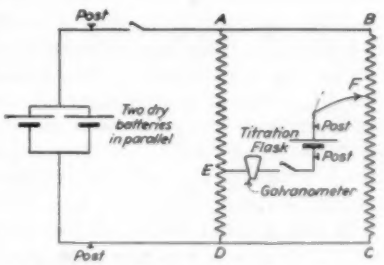

FIG. 1.—Roberts Titration Potentiometer showing wiring diagram.

In the Roberts Titration Potentiometer we have a sliding contact *F*, making contact with the resistance coil *BD* divided into 200 equal divisions. In parallel therewith are two fixed resistances *AE* and *EC* in series with each other and having resistances in the proportion 140 to 60. *E* is connected to *F* through a galvanometer and the titration cell. Since *AB* and *CD* have negligible resistance *A* is at the same potential as *B* and *C* as *D*. That is, *AC* equals *ED* in voltage drop. The potential drop between *B* and *D* is proportional to the divisions. The potential drop of *AE* is to that of *EC* as 140 is to 60.

When contact is made across EF a current will flow and deflect the galvanometer unless the position of F is such that its potential, less that of the titration cell, is equal to that of E. Accordingly, if we adjust F so that no current is indicated by the galvanometer, the reading $F-60$ is proportional to the potential of the titration cell. For the purpose to which the Roberts is put, direct readings of F, an arbitrary measure of the potential, are sufficient, for the addition of 60 to the potentials merely shifts the whole volume-potential curve, upward without altering its shape.

The calomel electrode is assembled by placing in the bottom of the arm about $\frac{1}{4}$ inch of freshly cleaned mercury. (Cleaned by filtering, or washing with nitric acid). Then $\frac{1}{4}$ inch of dry calomel is placed on top of the mercury and water or brine added to moisten the calomel. Stirring will help wet the calomel. However, care must be taken not to mix with the mercury. Then connect with the brine and be sure to sweep out all bubbles and allow the brine time enough to displace the water in the calomel. The wires leading from the platinum connections on the half cell to the potentiometer are conveniently annunciator wire.

The platinum electrode should occasionally be ignited in a flame. It should be kept standing in hydrochloric acid.

Procedure To determine electrometrically the iron in any glass or glass-making material it is first necessary to get the iron into solution in 1:1 hydrochloric acid. For the methods of effecting solution see the particular material under consideration.

Having obtained solution of the iron in 1:1 hydrochloric acid (150 cc) in a 500 cc Erlenmeyer flask, bring the acid solution to boiling, let cool so that the flask can be shaken by hand, add the minimum number of drops of stannous chloride in hydrochloric acid (usual qualitative reagent) to decolorize the ferric iron. Wash the titration head with distilled water and flow out a few drops of brine from the salt bridge to prevent contamination from the last analysis. Insert the titration head in the Erlenmeyer and insert the tip of the buret through the hole provided in the titration head.

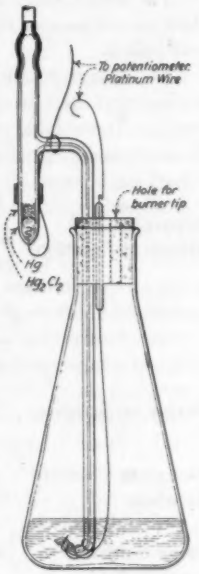

FIG. 2.

Close the switches on the Roberts potentiometer and balance the potentiometer. (Turn the wheel so that the galvanometer reads zero). Shake the solution well and again balance. If the reading of the potentiometer is less than 70, add a few cubic centimeters of potassium dichromate solution, shake well and balance the potentiometer. If the potentiometer reading is over 70, oxidation of the stannous chloride by the air is a sufficient factor to cause a continuing shift in the potential. This oxidation will destroy all the stannous chloride in a few minutes. The air will also oxidize ferrous chloride, so that it is necessary to start the titration just as soon as the end point of the stannous chloride is reached. This point with new batteries is 85–90 and with old batteries 95–100.

It is determined as half-way between the last stable potential while stannous chloride is in the solution and the first stable potential after the stannous chloride is all destroyed. Another means of identifying this point is that at this point the solution begins to turn faintly yellow.

The buret reading at this point should be noted for it is the beginning point of titration. Add quickly a considerable amount of potassium dichromate solution, shake and balance. Govern the next addition of potassium dichromate by the potential obtained on each previous addition. As the end point is approached, decrease the additions to 1/100 of the total titration and record the titration and corresponding potentials. As the end point is approached, after each addition, shake and balance repeatedly until a

constant balance is established. Continue additions beyond the end point until each addition produces less than one-third of the greatest change produced by any equal addition.

Plot the curve of the potential against buret readings and determine therefrom the point of inflection. After a little practice it is possible to estimate the point of inflection by an inspection of the potentials without drawing the curve. Subtract the reading of the buret at the beginning point of the iron titration from the buret reading at the end point (point of inflection last obtained). The difference is the measure of the iron oxide present in the sample.

Calculation $\dfrac{\text{cc} \times \text{factor} \times 100\%}{\text{g. sample}} = \text{Fe}_2\text{O}_3 \text{ in sample}$

NOTE: If desired the titration may be repeated merely by reducing and titrating as before.

NOTE: It occasionally happens that a bubble gets in the capillary salt bridge and breaks contact, so that turning the potentiometer wheel makes no change in the galvanometer. The remedy is to flow enough of the brine to sweep the bubble out of the capillary.

Another cause of breaking contact is corrosion of the copper wires at the point of contact with the platinum wires. The junctions should be disconnected and the copper wires scraped. On re-connecting no trouble should be experienced.

Sand is likely to accumulate in the tip of the salt bridge. It does no harm as long as it is possible for the brine to flow slightly.

NOTE: Be sure the galvanometer needle comes to rest at zero when no current is flowing.

NOTE: In the procedure recommended by Hostetter and Roberts, the solution is blanketed throughout the titration by some nonoxidizing gas, as carbon dioxide. The carbon dioxide is introduced through the titration head by means of a t-tube, one leg of which affords a means of exit for the platinum electrode. The exit gases flow out around the buret tip.

This procedure is more strictly accurate than the one described above. It gives a smooth curve at the beginning point of the titration and eliminates the necessity for haste at that point. However, if the titration without the carbon dioxide blanket is conducted rapidly the same result is obtained as with the carbon dioxide. Twice as many titrations may be made in an hour without carbon dioxide and one is saved the nuisance of the carbon dioxide generator.

NOTE: The end point in the determination of iron in sand is more sharp than in the determination of iron in lime or feldspar. More care is therefore necessary in following the potential changes in these cases than with sand.

NOTE: Nitrates interfere with the titration owing to their slow and continuing tendency to oxidize the stannous chloride and ferrous chloride. They should be destroyed before starting the titration. Removal is effected by precipitating the iron as hydroxide and filtering off the liquid, then redissolving the iron. Filtrates may be destroyed by long continued boiling with an excess of stannous chloride.

NOTE: The method is independent of the presence of titanium for the reduction potential of titanous chloride is similar to that of stannous chloride, so that it is all oxidized before the ferrous chloride begins to be affected.

The method is independent of the presence of chromium, for it would be converted to chromic chloride by the stannous chloride and chromic chloride is one of the products of the reaction.

NOTE: Copper is included in the results, as its curve is very closely like that of iron.

Vanadium is included in the results, but is not apt to be met with.

THE DETERMINATION OF IRON AS Fe_2O_3 IN GLASS SANDS BY THE ELECTROMETRIC METHOD

Weigh a 10-gram sample of the sand into a platinum dish of 150 cc capacity. (It is not necessary to grind the sand). Moisten the sample with distilled water and add 2 cc concentrated sulphuric acid. Mix thoroughly by shaking the dish. Hydrofluoric acid (C. P. 48%) is now added until a few drops no longer produce any reaction.

NOTE: This reaction is not violent unless the sand is ground.

Fill the dish with hydrofluoric acid, place on the sand bath or hot plate, and evaporate. The sand becomes flocculent and may completely dissolve. In the latter case, the evaporation is carried to sulphuric acid fumes, rapidly at first, then carefully to avoid loss by spattering.

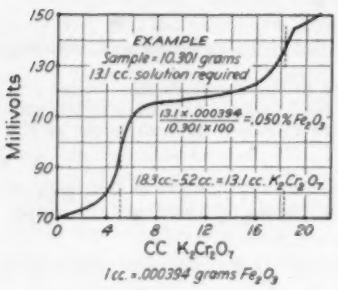

FIG. 1

In case the solution is not complete, carry the evaporation down half way, then refill the dish with hydrofluoric acid and evaporate to sulphuric acid fumes and dryness.

Ignite the dish containing the residue for a few minutes at 1800° F to drive off any excess sulphuric acid and burn out any organic matter that may be present.

Cool the dish containing the residue and add 25 cc hydrochloric acid 1:1, cover with a watch glass, heat to boiling and filter into a 500 cc Erlenmeyer flask. Wash the filter paper three times with hot water.

Return the paper to the dish and ignite. Make a quick fusion with sodium carbonate (2 grams, 5 minutes). Dissolve the melt with hydrochloric acid 1:1 and add to the Erlenmeyer flask, disregarding any silica that may have been carried over. Add hydrochloric acid 1:1 (and concentrated hydrochloric acid equal to the volume of wash water used) to bring the volume up to 150–200 cc. Cover with a watch glass and heat to boiling. Cool the neck of the flask with a stream of cold water. Reduce the iron with stannous chloride (minimum number of drops). Adjust the titration head, insert the buret tip, and titrate with standard potassium dichromate solution, while recording the potential by means of a Roberts Electrometric Titration Apparatus. From the potential titration curve ascertain the number of cubic centimeters of potassium dichromate solution required by the iron chloride in the solution.

Calculate the percentage of total iron as iron oxide. Report as iron oxide. A blank is run on the reagents used and the blank subtracted from the titration.

REPORT OF THE COMMITTEE ON "THE USE OF THE WORD "ENAMEL"."[1]

1. The use of the word "enamel" for certain kinds of gloss type paints is so well established that this Committee reports that it cannot hope to keep the paint manufacturers or producers of painted metal products from using this designation.

2. It is recommended that in describing porcelain or vitreous enamels that one or both of these adjectives be used.

3. It has been suggested that a new word might be coined to use for enamel that could be trade-marked, similar to the way in which the manufacturers of artificial silk have coined and used the word "Rayon" for their product.

[1] Submitted by R. D. Landrum, *Chairman.*

NEW MEMBERS RECEIVED FROM FEBRUARY 19 TO MARCH 15

CORPORATION

The Central Alloy Steel Corp., Massillon, Ohio. F. M. Portz, representative.

The Conover Co., 310 S. Michigan Ave., Chicago, Ill. M. R. Ferris, representative.

Midwest Fire Brick Construction Co., Stephenson Bldg., Detroit, Mich. Chas. M. Pease, representative.

PERSONAL

A. Raymond Brown, Hadfield-Penfield Steel Co., Bucyrus, Ohio.

Robert B. Burr, 103 Pacemont Rd., Columbus, Ohio. Industrial Engineer, Logan Gas Co.

John A. Cullen, Supt., Yankee Hill Brick Mfg. Co., Lincoln, Nebr.

G. G. Hanson, 2642 N. Mozart St., Chicago, Ill. Sales Representative, Erwin Feldspar Co.

W. A. Heisel, Chas. Taylor Sons Co., 1225 Glenlake Ave., Chicago, Ill.

Hermann Knuth, Bonn a. Rhein, Bahnhofstrasse 42, Germany.

Adam F. Moranty, 1271 Union Trust Bldg., Cleveland, Ohio. District Manager, Leeds and Northrup Co., Philadelphia, Pa.

Wilson A. Philips, 309 Fifth Ave., New York City.

*__Roy W. Schweiker,__ 509 Derstine Ave., Lansdale, Pa. Vice President and Superintendent, Franklin Pottery.

Olin K. Smith, United Light and Power Engineering and Construction Co., Davenport, Iowa. Chemical Engineer.

Robert W. Sneddon, G. P. O. Box 1536, Wellington, New Zealand.

Simon H. Stupakoff, Secretary and Manager, the Stupakoff Laboratories, 6627 Hamilton Ave., Pittsburgh, Pa.

Kasper Olaf Swenson, 78 New Bond St., Worcester, Mass. Norton Co.

Paul H. Taylor, 307 N. Michigan Ave., Chicago, Ill. District Manager, Leeds & Northrup Co., Philadelphia, Pa.

James G. Thompson, 5045 Lindell Blvd., St. Louis, Mo. Laboratory Assistant, Laclede-Christy Clay Products Co.

Walter J. Troy, 93 Melrose St., Rochester, N. Y. Asst. Chemist, The Pfaudler Co.

*Received at Detroit Meeting.

STUDENT

Charles H. Commons, 1212 W. University Ave., Urbana, Ill.

Frank J. Fallon, 810 W. Springfield Ave., Urbana, Ill.

Thomas M. Felton, Dept. Ceramic Engineering, Ohio State University, Columbus, Ohio.

Edward L. Harcourt, 44½ E. Norwich Ave., Columbus, Ohio.

N. O. Alex Kleerup, 212 E. Chalmers St., Champaign, Ill.

Perry C. McCallum, 503 N. Lake St., Urbana, Ill.

Earl F. McDonald, 603 E. Springfield Ave., Champaign, Ill.

Lane Mitchell, 850 Penn Ave., N. E., Atlanta, Ga.

Richard S. Moore, 6959 Paxton Ave., Chicago, Ill.

Theodore H. Palmer, 125 N. Logan Ave., Danville, Ill.

Walter E. Williams, 401 Allen Street, State College, Pa.

Geo. Wolfram, 212 E. Chalmers St., Champaign, Ill.

MEMBERSHIP WORKERS' RECORD

CORPORATION			
George Blumenthal	1	Office	1
F. H. Riddle	1	Total Corporation	3
PERSONAL			
Hugo Akermann	1	H. G. Parsons	1
Henry Brewer	2	E. E. Pressler	1
J. L. Crawford	1	Malcolm A. Schweiker	1
W. A. Darrah	1	Office	6
E. E. Geisinger	1		
Arthur T. Malm	1	Total Personal	16
STUDENT			
A. I. Andrews	3	E. J. Vachuska	2
R. K. Hursh	3	Office	1
C. W. Parmelee	2		
J. B. Shaw	1	Total Student	12
		Total	31

NEWS FROM MEMBERS OF THE SOCIETY

Albert S. Aldcock has been transferred from the Tiffin, Ohio plant of the Standard Sanitary Manufacturing Company to the Richmond, Calif. plant.

Henry N. Baumann, Jr., formerly a ceramic student at the University of Washington, Seattle, Wash., is employed in the research department of the Carborundum Company, Niagara Falls, N. Y.

Robert C. Boyd, recently ceramic engineer for the Chicago Hardware Foundry Company, has become affiliated with the Standard Sanitary Mfg. Co., 2801 Preble Ave., Pittsburgh, Pa.

Miss Mabel C. Farren, active in Art Division work of the Society for several years, is located at Laguna Beach, Calif.

On March 1, **Fred B. Garrod,** chemist for the Owens Bottle Company, was transferred from Toledo to their plant at Charleston, W. Va.

S. E. Hemsteger, who has been associated with the Mt. Clemens Pottery Co., Mt. Clemens, Mich., has recently joined the Research Department, Standard Sanitary Mfg. Co., Pittsburgh, Pa.

T. A. Klinefelter moved to Columbus, Ohio in February from Washington, D. C. Mr. Klinefelter is superintendent of the Ceramic Station, Bureau of Standards, located in Columbus.

Wm. H. Landers, formerly of Collinsville, Illinois, has moved to Oakland, Calif.

Michael Maloney is no longer with the Glascote Co., Euclid, Ohio, but is affiliated with the Davidson Mfg. Co., Montreal, Canada.

J. Burnett Matson has moved from West Chester, Pa. to Rochester, N. Y. where he is connected with the Mechanics Institute.

On March 1, **Samuel J. McDowell** took up his new position with the Corning Terra Cotta Company, Corning, N. Y. Mr. McDowell was formerly superintendent, U. S. Bureau of Standards, Columbus Station, Columbus, Ohio.

Richard G. Mills has moved from Champaign, Illinois, to Cayuga, Indiana.

Ralph J. Paddock is located with the Pittsburgh plant of the Standard Sanitary Mfg. Co., having left the U. S. Gypsum Company at Gypsum, Ohio.

H. A. Rossell, Tennessee Mineral Products Company, has moved to Spruce Pine, N. Car., from Bristol, Tenn.

W. W. Tsou, who attended the University of Illinois last year, is located at Sheffield, England, University of Sheffield.

Bruce F. Wagner has moved from Rochelle, Illinois, to 4150 E. 56th St., Cleveland, Ohio.

Tso Ming Wu, a student in the ceramic department at Ohio State University, has moved to Wheeling, W. Va., where he is employed.

IN MEMORIAM

Oliver Otis Bowman

Oliver Otis Bowman, Trenton, N. J., frequently referred to as the dean of the manufacturers and bankers of that city, died at the McKinley Hospital, Trenton, Dec. 5, 1926, aged 88 years.

Mr. Bowman was born August 23, 1838, at Wilkes-Barre, Pa.; was educated in the public schools of that city. He later attended the Weissport, Pa., Seminary. In 1859 he took over the business of Bowman Brothers, a general mercantile concern, in Perryville, and conducted this enterprise until 1862, when his store was swept away by the swollen waters of the Lehigh River, a flood which nearly cost him his life. After the inundation, he was awarded the contract for rebuilding part of the damaged canal in the vicinity.

After serving in the Civil War as a member of the Nineteenth Pennsylvania Volunteers, he came to Trenton to engage in the manufacture of terra cotta and bricks under the firm name of O. O. Bowman & Company, which was succeeded in 1877 by the Trenton Fire Clay and Porcelain Company, of which he was president. This grew to be one of the important industries of the city.

O. O. Bowman

It was largely due to Mr. Bowman's efforts as head of the latter concern that the removal of the J. L. Mott Iron Works from New York to Trenton was effected. For a time he was treasurer of the Mott concern.

He was one of the organizers and once president of the Broad Street National Bank and throughout his life was active in the interests of that institution.

Mr. Bowman was particularly prominent in the ceramic industry at Trenton, and his passing caused general sorrow among his many business friends and acquaintances, despite the fact that he had not been active since the injury which resulted in his death. His passing was not only a severe loss to the clay-working field in the state, but to the city of Trenton, where he had been so active in civic affairs concerning the welfare of the municipality.

REPORT OF THE CHAIRMAN OF THE EXHIBITION COMMITTEE (ART DIVISION)

The exhibition of ceramic art ware which was displayed at the Arts and Crafts Club during the meeting of the AMERICAN CERAMIC SOCIETY in Detroit in February was the finest which the Art Division has ever sponsored. There were more exhibitors than ever before and the art work shown was both varied in style and of high artistic value.

Through the efforts of Martha G. Westfeldt, Chairman of the Committee, an exhibit of Danish ware from the Royal Manufacture of Copenhagen was secured. Eight pieces were shown from the Dalgas exhibition as follows,

(1) Jais Nielsen, (one vase, grey stone ware with decoration underglaze and iron glaze), and (2), (one vase, turquoise blue stone ware), (3) Knud Kyhn, (one animal in stone ware, half-matt glaze), and (4) (one animal turquoise blue stone ware), (5) Hans Hansen, (one vase, Celadon porcelain), (6) Gerhard Henning, (one figure, overglaze decorated porcelain), (7) A. Malinowski, (one figure in biscuit, soft china), (8) N. Tidemand, (one vase in grey crackled porcelain, decorated overglaze, special rough body).

A loan exhibition of French ware included nine pieces.

(1) Lenoble, (Persian blue vase), and (2) (white decorated bowl), (3) De Coeur (white vase), (4) De la Herche (white porcelain vase), (5) Mayadon (Persian blue), (6) Simmen (white vase, coral top), (7) Serre (cream-colored decorated vase), (8) Massi (minuscule), (9) Sèvres (biscuit lamb), (10) Decorchemont (blue glass vase).

Three other Danish pieces were also shown,

(1) Jais Nielsen, (Celadon incense burner), (2) Henning, (girl with mirror), (3) Bing & Grondahl (small white bowl).

The latter Danish and French ware were pieces owned by Mrs. Westfeldt and shipped from New Orleans for use at the Meeting.

In the United States, thirty companies and individuals were solicited and eighteen replied by sending an exhibit. Nine declined for various reasons, chiefly because there was nothing new to show or they were too busy and only three failed to reply.

Those who exhibited from this list were,

American Encaustic Tiling Co., 16 East 41st St., New York City, Leon V. Solon, Art Director.

Art Institute of Chicago, Chicago, Ill. Myrtle M. French, Instructor Pottery Dept.

Batchelder Wilson Co., 101 Park Ave., New York City.

Boston Pottery Work Shop, 79 Chestnut St., Boston, Mass. (A group of studio potters working together.) Ellen W. Cushing, Secy.

Chas. S. Connick, 9 Harcourt St., Boston, Mass., Leading designer and maker of stained glass windows.

Charles M. Harder, high school pottery, Peabody High School, 813 Collins Ave., Pittsburgh, Pa.

T. G. Hawkes & Co., Corning, N. Y., Samuel Hawkes, President. Glass Manufacturers, Grand Prize, Paris. Six pieces of crystal for exhibition.

Lenox Inc., Trenton, N. J., Frank G. Holmes, Secy. First White House dining service made in United States (by Lenox), Wilson administration.

Muncie Clay Products Co., Muncie, Ind., C. V. Grafton, Gen. Mgr. (Makers of sand crucibles and rainbow art pottery.)

Near East Relief, 151 Fifth Avenue, New York City, Fred M. McCallum. (Studio pottery done by children.)

Mrs. Bentley Nicholson, 1122 Jackson Ave., New Orleans, La. (Studio potter, hand-built tiles, bowls, etc. "Master craftsman.")

H. V. Poor, Rockland Company, New York City, N. Y., (Studio potter, free use of design.)

Mrs. Adelaide Robineau, 204 Robineau Road, Syracuse, N. Y. (Master craftsman. Delicate carved designs on porcelain, crystalline glazes, etc.)

Maud Robinson, Greenwich House Potteries, 27 Barrow Street, New York City. (Studio potter.)

Steuben Division of the Corning Glass Works, Corning, N. Y., Irving B. Cary, Mgr.
Zane Pottery Co., South Zanesville, Ohio, Leo J. Decker, Asst. Treas.
Paul St. Gaudens, The Chappell School of Art, Denver, Colo. (Can be reached at 338 W. 6th St., Claremont, Calif.) (Studio potter.)
Mrs. Robert Bowditch Stone, Woodland Road, Jamaica Plain, Mass.

Eighty members of the Art Division were solicited for samples of their work. Twenty-six of these accepted and forwarded an exhibit. These were:

Mrs. Lulu S. Backus, 451 S. Goodman St., Rochester, N. Y., Head Ceramic Dept. Mechanics Institute.
A. E. Baggs, The Cowan Pottery Studio, Rocky River, Ohio. Director Marblehead Pottery, Marblehead, Mass. and associated with Cowan Pottery Studio.
Charles F. Binns, Alfred, N. Y., Director New York State School of Clayworking and Ceramics, Alfred, N. Y. (Influence has been very great. Has produced a series of highfire copper reds of fine quality and color.)
May E. Cook, 1550 Clifton Ave., Columbus, Ohio. (Sculptor in glazed terra cotta and marble.)
Cowan Pottery Studio, Rocky River, Ohio, R. G. Cowan, President.
Russel G. Crook., South Lincoln, Mass. (Studio potter salt-glazed vases, polychrome tiles.)
Ellen W. Cushing, 138 Marlborough St., Boston, Mass. (Same as Boston Pottery Work Shop)
Flint Faience Tile Co., Flint, Mich. Ralph E. Hanna.
Marion L. Fosdick, Alfred, N. Y., (Instructor, Ceramic Art Classes.)
Myrtle M. French, Art Institute of Chicago, Chicago, Ill.
Fulper Pottery, Wm. H. Fulper, Flemington, N. J.
Green Shutter Pottery, 633 Royal St., New Orleans, La. Martha J. G. Westfeldt.
Iowa State College, Ames, Iowa. (Paul E. Cox., Director Ceramic Dept.)
Henrietta O. Jones, St. Louis School of Fine Arts, Washington University, St. Louis, Mo., Instructor of Ceramic Art.
Robert H. Louden, The National Tile Co., Anderson, Ind.
Newcomb School of Art, Newcomb College, New Orleans, La. Mary G. Sheerer.
Elizabeth G. Overbeck, Cambridge City, Ind. Overbeck Pottery.
Pewabic Pottery, Mrs. W. B. Stratton, 10125 E. Jefferson Ave., Detroit, Mich.
Mr. and Mrs. Frederick H. Rhead, Zanesville, Ohio.
Roseville Pottery Co., Zanesville, Ohio.
Schenley High School, Pittsburgh, Pa., Edna P. Carson.
Shearwater Pottery, Ocean Springs, Miss., Peter Anderson.
University of North Dakota, University Station, Grand Forks, N. Dakota. Margaret K. Cable, Instructor Ceramic Art.
Leon Volkmar, 3427 Cornell Place, Cincinnati, Ohio.
Harry Voorhees, Inwood Pottery, W. 207th St. and Ship Canal, New York City.
Mrs. Martha T. Weaver, Cleveland School of Art, 11441 Juniper Road, Cleveland, Ohio.

Among the replies listed from those who did not exhibit this year were many who expressed a desire to be allowed to present their ware at the 1928 meeting in Atlantic City.

OUR ADVERTISING RECORD

The accompanying curve shows for the years 1922–26 inclusive, the monthly average number of pages of advertising other than "classified" which the members of the SOCIETY have secured.

Advertisements in this *Journal* are for two purposes, (1) information and (2) income. The *Journal* is the tool or means by which the members exchange and preserve results of study, investigations, and observations. It is a costly means but the cost is at the minimum consistent with clear and full presentation in good style. Advertisements are

essential to sufficient income to permit of issuing such a *Journal* monthly and keeping the annual personal membership fees at the low sum of $10.00.

It is a surprise to those who know of the cost of association work and the cost of monthly journals of such high character and size that it is possible to keep the personal membership of this SOCIETY at such a low figure. Usually, for like association enterprises, the personal fees range from $15 to $25 with, too, an occasional assessment.

The SOCIETY's argument is that if it is to be of the maximum benefit to the ceramic industries it must keep its personal membership fee down to a figure which employees can pay. The securing of advertisements for the *Journal* is one of the means of making possible the participation in the benefits of membership in the SOCIETY by ceramic employees.

Advertisements in the *Journal*, however, serve another purpose; they disseminate information. In this respect the advertisements in the *Journal* are very much worth while. Even though financed by endowments sufficient to cover the printing costs of the *Journal*, there would remain the question of whether the SOCIETY would be justified in discontinuing the advertisements because of their educational value.

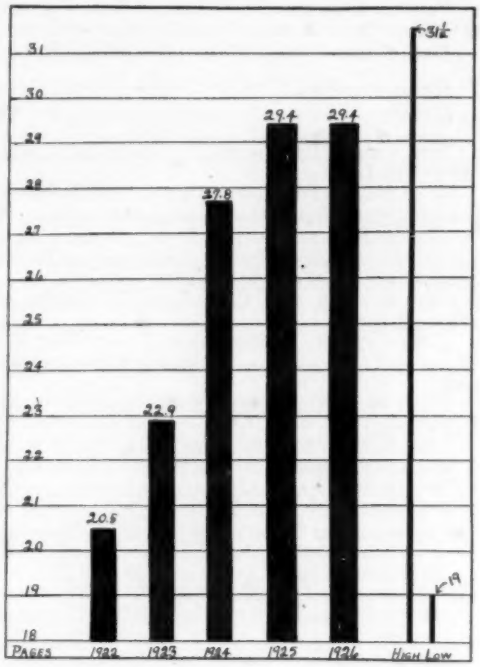

FIG. 1.—Advertising record for *Journal of the American Ceramic Society.*

The SOCIETY does not have a personal representative soliciting advertisements. The SOCIETY does not feature installations in modern plants nor does it allow of advertisements that do not give ceramic information. The SOCIETY is dependent on solicitation by the personal members from those firms known to have material or equipment which can to advantage be used in producing ceramic wares.

Those members who have not been assisting in securing and keeping the *Journal* advertising up to standard in quantity and quality by direct solicitation and by communication written or spoken with those firms who are advertising should remember that this is their enterprise and that the larger the advertising income, the more active can be the committees and much larger can be the amount of information recorded in the *Journal*.

LOCAL SECTION NOTES

The St. Louis Section[1]

The members of the St. Louis Section, AMERICAN CERAMIC SOCIETY held a meeting on March 4, 1927 at The American Annex Hotel. Following dinner, the meeting was called to order by Chairman Crawford at 8:00 P. M.

[1] C. C. Lake, *Secretary.*

An excellent talk on geology, illustrated by many colored slides, was given by Dean W. E. McCourt of Washington University. Dean McCourt used the beautiful canyon country of Arizona and southern Utah to show the formation of rock and the effect of erosion by wind and water.

A résumé of the papers read at the Detroit Meeting was given by several of the members who attended.

H. W. Perry reported the progress of the Smoke Abatement League in its efforts to educate the householder as well as the industrial plant in correct firing methods so as to reduce smoke to a minimum.

J. L. Crawford reported that the Ceramic School at the Rolla School of Mines was now established with Dr. M. E. Holmes in charge, and that the school could make the general tests of raw material or finished product as required by the industry.

Following the program, election of officers was held and the following officers were unanimously elected to serve during the ensuing year;

C. H. Modes, Chairman
F. E. Bausch, Vice-Chairman and Councillor
C. C. Lake, Secretary
H. W. Perry, Treasurer

Those present were:

Dean W. E. McCourt, Washington University
F. E. Bausch, Frederick E. Bausch
Laclede Gas & Light Company
E. P. Bell
C. E. Hartwein
W. H. Hoagland
W. D. Thompson
T. E. Wood
C. O. Wright
Evens and Howard
H. B. Stone
B. W. Wilson
Russel Engineering Company
W. W. Aulepp
J. Cox
C. C. Lake, Parker Russell Mining & Mfg. Company
Laclede Christy Clay Products Company
H. P. Williams
L. C. Hewitt
H. W. Perry
W. F. Godejohn
J. L. Crawford
J. B. Ives
L. H. Blue
J. G. Thompson
H. E. Johnson
H. W. Perry
F. G. Jaeger, Superior Enamel Products Company
F. H. Schwetye, Mo. Fire Brick Company
J. S. Groppe, Highland Fire Clay Company
L. M. Diven, Blackmer and Post Pipe Company
A. D. Oetjen, Standard Oil Company

REPORT ON THE NORTH CAROLINA STATE STUDENT[1] BRANCH OF THE AMERICAN CERAMIC SOCIETY

The past year and especially the past half-year has been the most successful in the short history of this Branch. Interest in the meetings has been constantly growing and the attendance has been splendid, due largely to the leadership of this year's president, P. E. Trevathan and the chairman of the Program Committee, L. R. Whitaker. Mr. Whitaker has arranged for a special speaker for each meeting held during this college year. Each program has also included addresses by two members who have been encouraged to speak extemporaneously. The students have taken as their subjects their experiences on summer work.

[1] A. F. Greaves-Walker, Councillor

The principal speakers and their subjects were as follows:

J. L. Stuckey, State Geologist, "The Shales of North Carolina."
J. G. Vann, "Selling Clay Products."
G. M. Norwood, President, Norwood Brick Company, "The Future of Ceramic Engineering in the South."
Bruce Drysdale, President N. C. Clayworkers Assn., "The Future of the Ceramic Industry in North Carolina."
J. G. Moland, President Moland-Drysdale Corp., "West Indies Travelogue."
A. F. Greaves-Walker, Ceramic Department, North Carolina State College, "Artistic Brickwork."
G. R. Shelton, Ceramic Department, North Carolina State College, "Colloids."

The Branch has been making plans and preparations for its part in the program for Engineer's Day and will have a float in the parade and ceramic souvenirs for the Engineer's Fair. One of the members, A. McK. Greaves-Walker, was elected manager of the Fair by the Engineering students.

Fifteen new members were initiated at the beginning of the college year, making a total membership of thirty.

The Treasurer's report is as follows:

Dues collected	$37.00
Expenditures	31.50
Balance on hand	$ 5.50

The officers for the year are:

P. E. Trevathan, President
A. McK. Greaves-Walker, Vice President
W. L. Stafford, Secretary-Treasurer

P. E. Trevathan
A. McK. Greaves-Walker } Representatives on Engineer's Council

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NOTES AND NEWS

AMERICAN REFRACTORIES INSTITUTE MEETING

The spring meeting of the American Refractories Institute will be held at Atlantic City, N. J., Hotel Traymore, May 18 and 19. The first day of the meeting will be taken up by a business and technical session and on the second day there will be a golf tournament.

GERMAN CERAMIC SOCIETY ANNOUNCEMENT

Members of the German Ceramic Society will meet in Berlin in October, 1927. An exhibit of "Ceramic Masters' and Scholars' Work" is being drawn up for the occasion, according to the plans, and models, from the work of teachers and students of all German polytechnic schools will be shown so as to usher in a union of the industry with the artistic aftergrowth.

At the same time a "Materials Convention" will be held at which German industry will coöperate, both ceramic materials and ceramic methods of testing being demonstrated.

Members of the AMERICAN CERAMIC SOCIETY are invited to attend this meeting if they are in Europe at the time.

SOCIETY OF GLASS TECHNOLOGY

Meeting of January 18 and 19

At the meeting of the Society of Glass Technology held in Manchester on January 18 and 19, 1927, the following papers were presented:

1. The Effect of Cullet on the Melting of Glass. By W. E. S. Turner. In the course of his remarks Prof. Turner said that cullet was used largely for economical reasons and the desire to use waste materials. The amount of cullet mixed in batches might vary greatly according to the type of glass being made and according to the method by which the glass was being worked out.

The questions they had to consider were: what was the effect on the melting and on the working of glass, and what was the cause of the change in the working properties of glass as the amount of cullet changed. It had been stated, said Prof. Turner, that manufacturers using all cullet never succeeded in getting seed-free glass. With regard to the influence of cullet on the working properties, it would appear that after a certain proportion of cullet was reached, the glass became stiffer and stiffer to handle. The important question was, how much cullet could be employed, especially in machine working. With a large proportion of cullet in the batch, the viscosity of the glass tended to become high and the working range to become shorter. Why did this happen? The usual explanation was that there was a volatilization of alkali and the glass became stiffer. Experiments, however, did not substantiate this, as was indicated in the results of certain meltings. V. H. Stott in a recent paper to the Society, found that it was only between 1500° and 1600°C that volatilization of alkalis began to be a factor. Was there then some change in molecular state which influenced the viscosity? How far real viscosity was affected was a problem still to be settled. There was something far more reaching than change of chemical composition.

2. Investigation of the Glassy State by the Method of Forced Crystallization. By J. F. Ponomareff, Tomsk, Siberia. In glass the ability to spontaneous crystallization was so weakly expressed and its speed was usually so small, that in ordinary conditions of cooling the molecules of glass had no definite position in the space lattice which accounted for the formation of the crystalline structure. Accordingly the substance chilled in an amorphous state producing a glass. The method of forced crystallization made it possible to crystallize every glass and to determine the temperature of the beginning of crystallization, as well as the melting point of the newly-formed crystals. In the glass under investigation a constant lowering of temperature was maintained, so that the temperature was reached at which the number of spontaneously forming nuclei reached its maximum value. This value could be very small, as in his study of acid borates of sodium in mixtures approaching pure B_2O_3, which he was obliged to maintain at such temperature condition for three weeks uninterruptedly until the crystals began to form.

The method of forced crystallization could be used for determining the temperature and speed of devitrification. It should also be used in research work with organic pitch-like substances which resemble glasses in their properties; also in the case of carbohydrates, glycerine and explosives. In conclusion Prof. Ponomareff gave a definition of glass which he believed to be the first approach to a precise characterization of glass. His definition was "A substance is to be regarded as a glass, independently of its chemical composition, which, being a strongly undercooled fusion, gives on crystallizing from the molten mass, crystals of the same chemical composition as the mass itself."

3. The Durability of Some Soda-Lime-Magnesia Glasses. By Violet Dimbleby and W. E. S. Turner. A series of glasses was tested by the powder method. The first member of the series was obtained by the replacement of 0.2 molecule of CaO by 0.2 molecule of MgO, in the parent glass, $6\ SiO_2 : 1.2\ Na_2O : 0.8\ CaO$. Succeeding members of the series

were obtained by the gradual replacement of CaO by MgO molecularly. The boiling reagents used were water, hydrochloric acid of constant boiling strength, and twice normal caustic soda solution.

From the results obtained it was concluded that the gradual molecular substitution of magnesia for lime produced the following effects: (1) durability toward boiling water was slightly enhanced, (2) resistance to attack by boiling hydrochloric acid was slightly impaired, (3) resistance offered to action of boiling caustic soda solution was somewhat decreased.

4. The Present Position of the Glass Industry in Germany. By W. E. S. Turner. The greatest concentration of the glass industry in Germany was in the Lausitz district; indeed, the Germans claimed this to be the greatest concentration of glass works in the world. There were two sections of Silesia in which one encountered a number of works, some of which were, in a way, relics of the former mountain and forest industry. Saxony had a strongly developed glass industry. Dresden could boast of a number of glass factories. Then there was Thuringia which was a strong center. On the western borders of Bavaria, also, touching upon Czechoslovakia, one came across another glass center, while in the Saar district there was a considerable glass industry. Similarly, in the district between Cologne and Essen there was a strongly developed industry, and a still further group of factories as one came into the neighborhood of Aix-la-Chapelle. Out of about 350 factories which existed in Germany in 1924, not more than between 50 and 60 were concerned with glass bottle production. The largest group of factories was that known as the hollow-ware group, which was identified with the production of all kinds of domestic articles. The manufacture of window glass and plate glass was also more widely separated than in Britain. Chemical and scientific glassware was produced in considerable volume, the Thuringian factories being particularly important from this particular aspect.

In regard to raw materials, the German manufacturer might be said to be well supplied, although in regard to fuel, supplies of hard coal were not so well-distributed as in England. The Lausitz district, for instance, had depended almost entirely for its fuel supplies on the enormous beds of brown coal situated thereabouts. In respect to other raw materials Germany was particularly fortunate.

German glass making had not undergone anything like such drastic changes since the war, as had been the case in England. In Germany sheet glass was still being produced by methods which did not involve continuous operation. The general expectance, however, seemed to be that within a year or two, the hand production of sheet glass would be a negligible quantity. In the making of electric light bulbs, automatic equipment was only just being installed. In the bottle section, conservatism was far deeper than in any other branch of the industry. The machines which had been developed were largely of the semi-automatic type.

It was noticeable that something had been done directly and definitely during the last four or five years to encourage research work in glass technology. In this connection such institutions might be mentioned as the one at Zwiesel; a trade school in Bavaria in which technique played a part; the technical school at Karlsruhe in which, in 1923, there was set up a department of glass technology; the high school at Hanover, where there was a section devoted to glass and ceramics; and the department of silicates which was opened in May 1926 at the Kaiser Wilhelm Institute in Berlin.

5. Developments in the Glass Industry in Russia. By J. F. Ponomareff (Tomsk, Siberia). One of the many difficulties encountered was the great distance which separated the various factories. Many works were run without having any technical or trained men in authority. The supplies of raw materials were good, there being plentiful deposits of sand and limestone. Sodium sulphate was obtained cheaply by evaporation from

natural lakes. Since the revolution the number of glass factories had been reduced from 200 to 100; some 40,000 laborers were now employed. Stress was laid upon the need for attracting young educated men to help in the development of the glass industry in Russia. At the same time it was noteworthy that the simple worker could do excellent work, although he was uneducated.

6. Owing to lack of time the reading of the following paper was postponed, namely, **"The Thermal Expansions of Some Boric Oxide Containing Glasses,"** by W. E. S. Turner and F. Winks.

Meeting of February 16

The meeting of the Society of Glass Technology held in Sheffield, February 16, 1927, was a joint one with the Yorkshire Section of the Society of Chemical Industry. The following bodies also took part: The Sheffield Metallurgical Association, The Sheffield Section of the Institute of Metals, and The Sheffield Society of Engineers and Metallurgists. The meeting was devoted to a general discussion on "Silicate Analysis." The following papers formed the basis of the discussion:

1. A Critical Survey of the Method in Use for the Analysis of the Simple Glasses. By W. H. Withey. The glasses comprised in the scheme normally contained silica, iron oxide, alumina, manganese oxide, magnesia, soda and potash, with sulphate, chlorides, and sometimes the oxides of arsenic and antimony in small proportions. The soda-lime series of glasses was included, and lead glasses differed only in that they contained lead. Borosilicate glasses containing zinc, and other glasses of more complex composition were excluded. Attention was directed only to criticisms of methods and recommendations as to the best procedure in order to insure the most accurate results. Referring to the question of the limits of accuracy possible in glass analysis, the author pointed out that the adoption of any standard became naturally a matter for personal opinion and experience. It was not unreasonable to suppose, however, that the limits of accuracy for the major constituents were in the order of 0 ± 08, calculated on the weight of the original material, and that the total for the best analyses should fall within the limits 99.75 to 100.20. A comprehensive examination of various methods was made under the following main headings: (1) general survey, (2) the precise determination of the constituent oxides, (3) suggested scheme of analysis, (4) modifications of above scheme for approximate results for purposes of works control.

2. Notes on Methods Used in the Analysis of Glasses. By Violet Dimbleby. Stress was laid upon the precautions to be observed in the determinations of silica and alumina, even in the case of the simple glasses. There was great need for careful washing and for control of the temperature of "baking" the silica; for the latter the use of high temperature was strongly condemned. Experiments made with pure rock crystal indicated that nothing was to be gained by this practice, and when other constituents were present with the silica, as in a glass, serious contamination of the silica would arise. Passing to the study of the more complex glasses, consideration was given to the determinations of ferric oxide, ferrous oxide, manganese oxide, arsenious and arsenic oxide, lead oxide, titania, zirconia, zinc oxide, cobalt oxide, baryta, boric oxide, sulphur trioxide, chloride, and fluoride. Difficulties that were likely to arise, and the precautions or modifications that were necessary under certain conditions, were indicated. The choice of method for the determination of any one of the constituents of a complex glass was determined by the qualitative analysis of the glass; that is, by the nature of the other constituents present. Reference was also made to alternative methods which might be adopted in some cases, where speed was of more count than absolute accuracy.

3. The Analysis of Refractories. By W. J. Rees. In the case of most refractories the finest grinding of the sample before fusion was necessary, while for a glass an exceedingly fine division was not absolutely necessary. For fire clays containing 3% or

more of iron oxide and titania, it was undesirable to heat the evaporated fusion at a temperature higher than 105°C. He found that above 105° there was an increase in the contamination of the silica. He contented himself with evaporating on a water bath. He seconded Mr. Withey's recommendation of the use of methyl red as an indicator; it was very useful in cases where the materials contained large proportions of lime and magnesia. Reference was then made to the analysis of magnesite bricks, basic dolomites, sillimanite, chrome refractories and silica bricks. Sillimanite gave trouble in analysis unless care was taken in the fusion. For the determination of alkalis in fire clays, the author relied on the Lawrence Smith method. He expressed his great interest in a suggestion made by W. Rosenhain in the course of the discussion of Miss Dimbleby's paper, namely, the use of superheated water for the first breakdown of the original material. He (Mr. Rees) had tried the method in a small way, without getting very good results. The method, however, was worthy of further investigation.

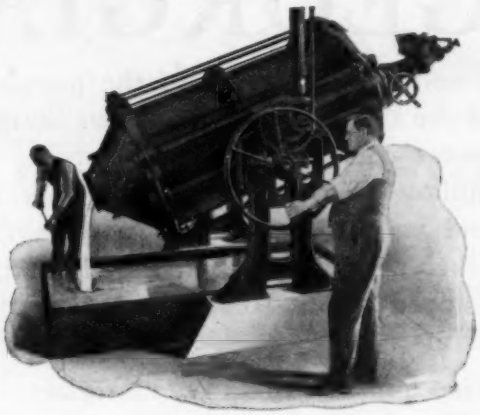
4. Notes on the Analysis of Silicate Slags. By T. P. Colclough. A close knowledge of the compositions of the slags formed in metallurgical processes was of fundamental importance, and methods for their rapid and reasonably accurate analysis were necessary. A table was given showing typical analyses of various kinds of slags, from which it was seen that the slags were generally much less siliceous than glasses. Methods were then indicated for the determinations of silica, iron oxide, alumina, phosphate, manganese oxide, lime, magnesia, sulphur and vanadic oxide. In addition to the more precise methods indicated, it was necessary, for the control of commercial processes, to be able to make analyses of slags for certain constituents, with sufficient rapidity and accuracy to be a guide to the person operating the plant. In each of the separate operations in iron- and steel-making at least one constituent of the slag was of vital importance in either the control of the operation or the manner of disposal of the material produced, and a method for the determination of that constituent must be available. A few examples were given to illustrate this point.

CALENDAR OF CONVENTIONS

AMERICAN CERAMIC SOCIETY		
Annual Meeting	Feb., 5–11, 1928	Atlantic City, N. J.
American Chemical Society	April 11–16, 1927	Richmond, Va.
Amer. Electrotechnical Soc.	April 28–30, 1927	Philadelphia, Pa.
Amer. Foundrymen's Association	June 6–9, 1927	Chicago, Ill.
Amer. Gas Association	Oct. 10, 1927	Chicago, Ill.
Amer. Inst. Chem. Engrs.	June 1–4, 1927	Cleveland, Ohio.
Amer. Refractories Institute	May 18–19	Atlantic City, N. J.
Amer. Soc. Mech. Engrs.	May 23–26, 1927	White Sulphur Springs, W. Va.
Amer. Soc. Steel Treating	Sept. 19–23, 1927	Detroit, Mich.
Amer. Soc. Testing Materials	June 20–24, 1927	French Lick, Ind.
Amer. Zinc Institute	April 18–19, 1927	Montreal, Canada.
Assn. Chem. Equipment Mfrs.	Sept., 1927	New York City
Exposition of Chem. Industries	Sept. 26–Oct. 1, 1927	New York City
Glass Container Assn.	April or May, 1927	?
Manufacturing Chemists Assn.	June 2, 1927	New York City
Natl. Academy of Sciences	April 25–27, 1927	Washington, D. C.
Natl. Assn. of Stove Mfrs.	May 11–12, 1927	New York City
Natl. Safety Council	Sept. 26–30, 1927	Chicago, Ill.
Natural Gas Assn. of Amer.	May 17–19, 1927	Cincinnati, Ohio.
Stained Glass Assn. of Amer.	June 27, 1927	St. Louis, Mo.

U. S. Rotary Enamel Smelting Furnaces Give

SATISFACTION



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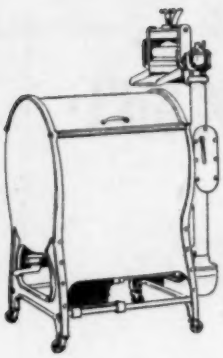

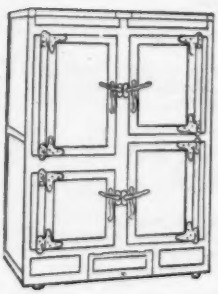

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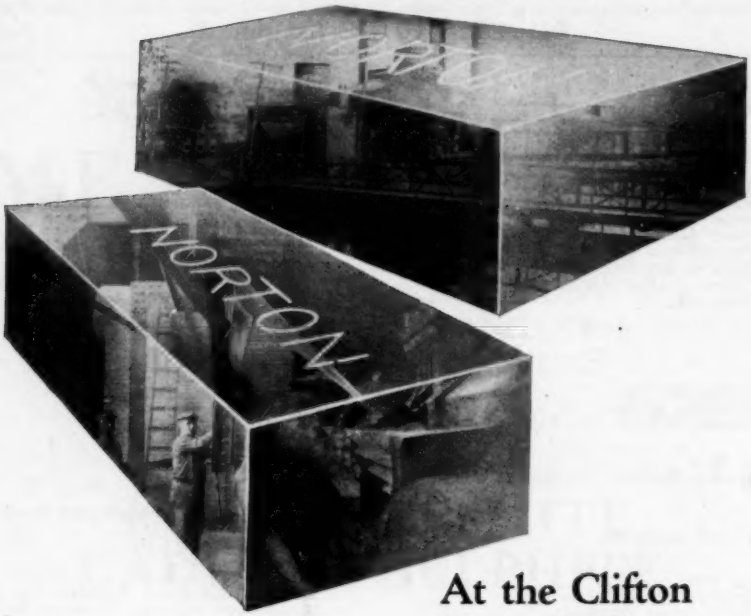

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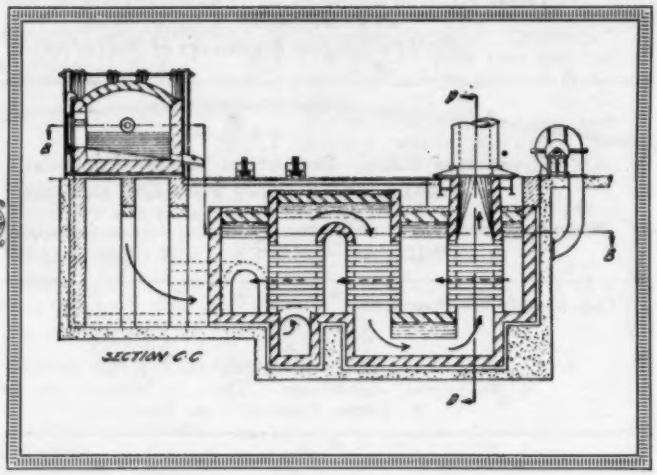

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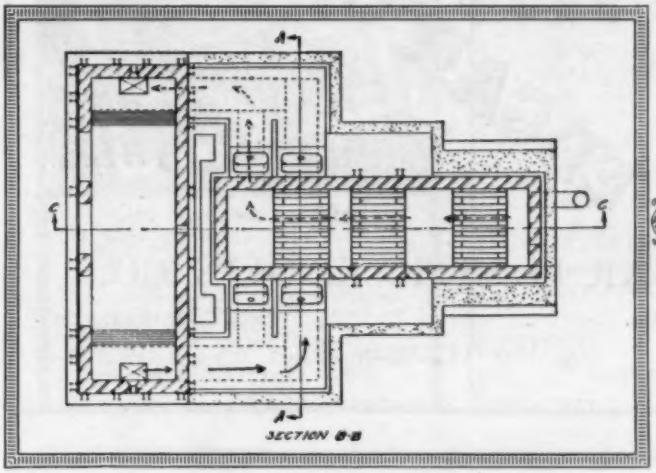

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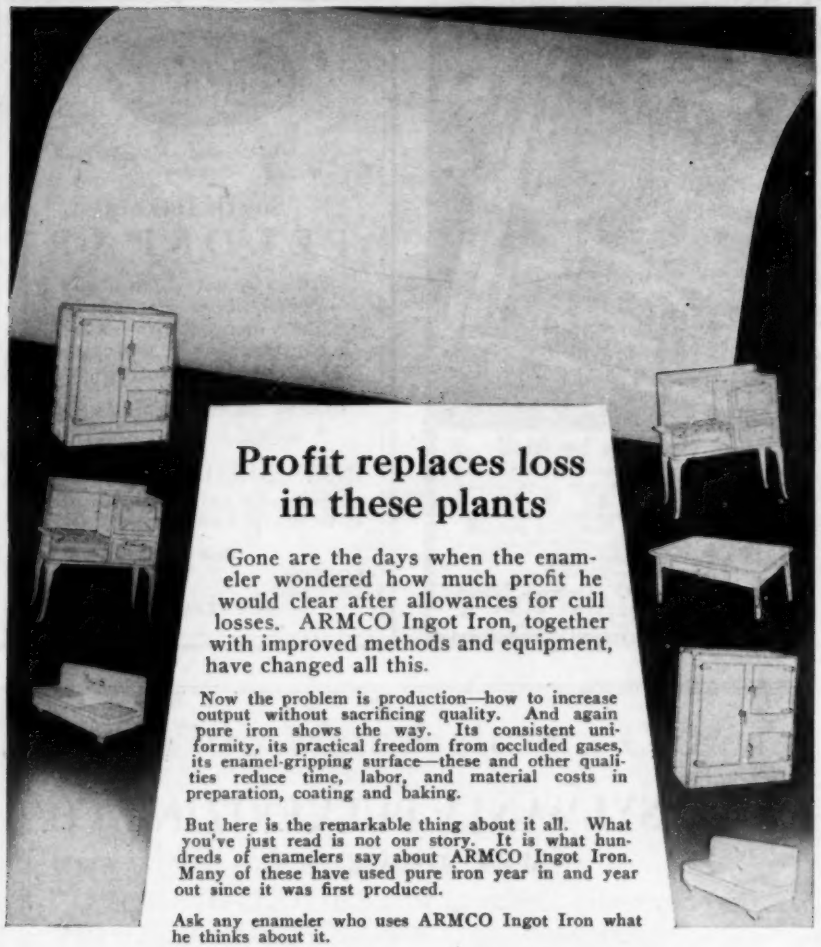

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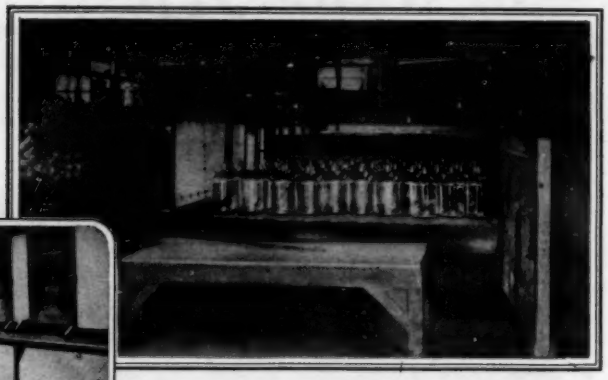

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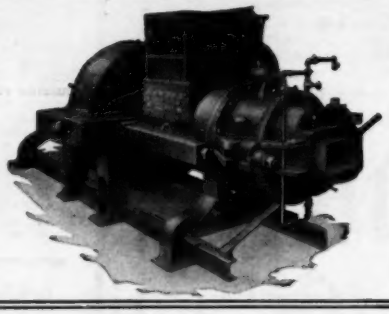

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